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PART II

SAND AND GRAVEL IN ONTARIO

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SAND AND GRAVEL IN ONTARIO

By

A. LEDOUX

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SAND AND GRAVEL IN ONTARIO

By A. Ledoux

Sand and gravel deposits are very numerous in the southern and eastern parts of Ontario. The author visited the most important of these during the summer of 1917. The region examined was practically the whole area of the Paleozoic formations in southern Ontario. Manitoulin Island was not visited; on the other hand, some small parts of the pre-Cambrian belt in the counties of Leeds and Frontenac and district of Muskoka were examined. In each county several of the typical deposits have been chosen and are described with regard to their geological conditions of occurrence and their economic value.

Scope of the Report

The report begins with a review of the characteristic properties of sand and gravel, and the methods of testing applied; these properties have been divided into morphological, physical and chemical. The following chapter deals with the origin and occurrence of these fragmental rocks. Such considerations are sometimes of practical interest, as there may be a close relation between the geological origin and the qualities of sand or gravel. In numerous cases continuous lines of deposits, marking ancient lake shores, may be followed in southern Ontario. On the shores of existing lakes, certain parts are marked by extensive beaches containing abundant reserves of good building material. Attention is also directed to some artificial sands made by crushing soft sandstones, suitable for special purposes such as glass-making and iron-smelting. Several deposits of this kind are worked in Ontario.

The classification of sands and gravels is practically based upon their several uses. The principal use is in connection with building industries. Sand and gravel for construction purposes are cheap, and yield only small profits per yard or ton. Other varieties, such as moulding sand and glass sand, are of greater value, but although these materials are found in the Province, they are ordinarily imported into Ontario.

Compared with most mineral products, the selling price of sand and gravel is very low, and the margin of profit depends upon skilful and economical operation. The small operator frequently produces for a time at low cost, but by unsystematic methods destroys the value of his reserves. The larger operators should pay particular attention to the introduction of labour-saving appliances.

The last chapter deals with the distribution of sand and gravel in southern Ontario. The several counties have been arranged alphabetically; the location of every described deposit has been indicated as far as possible, by its township, concession and lot. The most important sand and gravel producing areas are shown on a general map of southern Ontario (No. 27*b*) accompanying this report.

This report should be considered as only a preliminary one. Deposits in more than forty different counties were visited during four months of field work, thus allowing only a very short time for detailed examination of any deposit. Numerous granular metric analyses and physical tests of samples have

been made; it would be desirable to make a larger number of these tests, accompanied by chemical analyses and tests of mortars and concretes made from the materials.

The writer desires to express his thanks to Prof. T. L. Walker and Prof. A. L. Parsons, of the Mineralogical Department of Toronto University, for assistance in the preparation and correction of this work. He also wishes to acknowledge his indebtedness to Prof. A. P. Coleman of the Geological Department, and to Prof. H. E. T. Haultain and R. F. C. Dyer of the Mining Department of the same institution, for valuable advice and the use of their laboratories.

Most of the experimental investigations were made at the Mineralogical Department of Toronto University.

The chemical analyses were made by the Provincial Assayer, W. K. McNeill and his assistant, T. E. Rothwell. Sketch maps illustrating the report were prepared for reproduction by W. J. Bell, Bureau of Mines Cartographer.

Statistical information has been kindly given by various city and county engineers, municipal officials and by pit owners. The writer would express to all his appreciation.

Properties of Sand and Gravel

Sand and gravel belong to the category of unconsolidated clastic rocks. The component fragments vary widely in size, some passing the 200-mesh sieve, others being more than one foot in diameter. Small grains and large fragments may be associated in the same sample. There is no natural limit between sand and gravel: for practical use, we call sand a material made of grains passing the ¼-inch screen, and gravel a material made of fragments retained on the ¼-inch screen: boulders are fragments larger than three inches in diameter.

Morphological Properties

Size.—The size of the component fragments of a clastic rock affects a certain number of its physical properties, such as specific gravity, absorption, and permeability. With regard to size, sands are ordinarily divided into fine, medium and coarse varieties, gravels into fine gravel, pea gravel and coarse gravel.

The classification of a sand or gravel is often made at sight, but more accurately by using sieves. A sieve is defined by the number of holes or meshes per linear inch; for instance, a 100-mesh sieve has 100 holes to the linear inch. A sieve may also be defined by the smallest linear dimension or *rating* of the hole, a ¼-inch sieve having holes of ¼-inch as their smallest dimension. This last method may be applied to screens with holes larger than one inch. It should be noted that there is a great difference between a 4-mesh sieve and a ¼-inch sieve, depending upon the diameter of the wire. If M represents the number of meshes to the linear inch, D the diameter of the wire in mm., the rating R is expressed in millimeters by the following equation:

$$R = \frac{25.4}{M} - D$$

The diameter D is most easily determined by means of a micrometer gauge or by microscopic measurement. The following table gives the number of meshes

to the linear inch, the diameter of the wire and the rating, for the series of sieves used in the accompanying metric analyses, except where otherwise stated:

Sieve	Diameter of wire	Rating	
Mesh	Mm.	Inches	Mm.
4	1.651	.185	4.699
8	.813	.093	2.362
10	.889	.065	1.651
20	.437	.0328	.833
28	.318	.0232	.589
48	.234	.0116	.295
80	.1425	.0069	.175
100	.1070	.0058	.147
200	.0530	.0029	.074

In some sands and gravels, the component fragments are of uniform size; in others they vary widely. This can be tested by granular metric analysis. The principle of such an analysis consists in passing a given amount of the material, say 100 to 500 grams, through a series of sieves, and weighing the amount of the sample retained on each of them after sufficient shaking. The results are given in the percentage of the whole *remaining* or *retained* on each sieve. To express the degree of fineness by a single figure, the percentages passing each sieve are added and the total divided by the number of sieves used. The result is called the per cent. of fineness; if the same set of sieves is used this figure may be used for comparing different sands and gravels. The following table gives the results of the granular metric analyses, and shows the difference in the per cent. of fineness between several grades of sand and gravel:

Sieve	A Fine Sand		B Medium Sand		C Coarse Sand		D Fine Gravel		E Coarse Gravel	
Mesh	Ret.	Pass.	Ret.	Pass.	Ret.	Pass.	Ret.	Pass.	Ret.	Pass.
4	0.0	100.00	0.30	99.70	32.85	67.15	49.80	50.20	80.00	20.00
8	0.0	100.00	3.10	96.90	39.20	60.80	63.85	36.15	83.40	16.60
10	0.0	100.00	6.40	93.60	42.50	57.50	69.50	35.50	84.65	15.35
20	0.0	100.00	16.80	83.20	54.10	45.90	79.10	20.90	87.00	13.00
28	tr.	100.00	25.70	74.30	69.30	30.70	85.55	14.45	89.45	10.55
48	1.25	98.75	60.00	40.00	93.85	6.15	94.45	5.55	98.65	1.35
80	2.00	98.00	93.25	6.75	97.95	2.05	97.55	2.45	99.80	0.20
100	5.70	94.30	98.40	1.60	98.75	1.25	98.55	1.45	100.00	0.00
200	41.50	58.50	99.15	0.85	99.60	0.40	99.30	0.70	100.00	0.00
Total		849.55		496.90		271.90		162.35		77.05
Per cent. of fineness		94.39		55.21		30.21		18.04		8.56

A: Silty sand, very fine. Camp Borden (Simcoe county).

B: Medium sand, Landshore Sand and Gravel Co. (Ontario county).

C: Coarse sand, Markus pit, Pembroke (Renfrew county).

D: Fine gravel, J. Creeper pit, Belleville (Hastings county).

E: Coarse gravel, Bray pit, Port Hope (Durham county).

The results of granular metric analysis may be represented by diagrams, taking as abscissae the ratings of the different sieves and as ordinates the percentage of material remaining on each of them. Joining the different points (fig. 1) we obtain a graphic representation of the granular metric analysis.

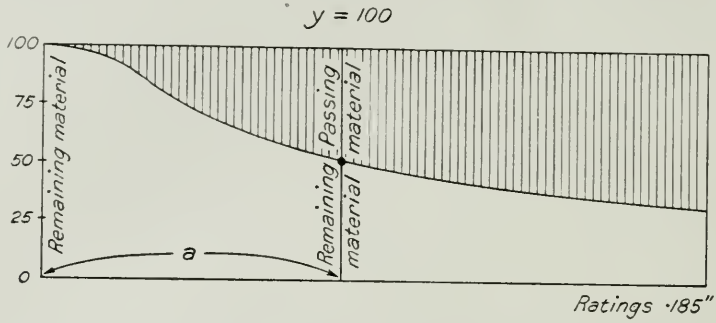

Fig. 1—Diagram of granular metric analysis. The shaded area is proportional to the fineness of the material.

On an ordinate X=a, the length measured between the curve and the axis of the abscissae indicates the percentage of material remaining on a sieve of a rating equal to *A;* the length measured between the curve and the line y=100 represents the percentage of material passing through the same sieve. The area comprised between the curve and the line y=100 is proportional to the fineness

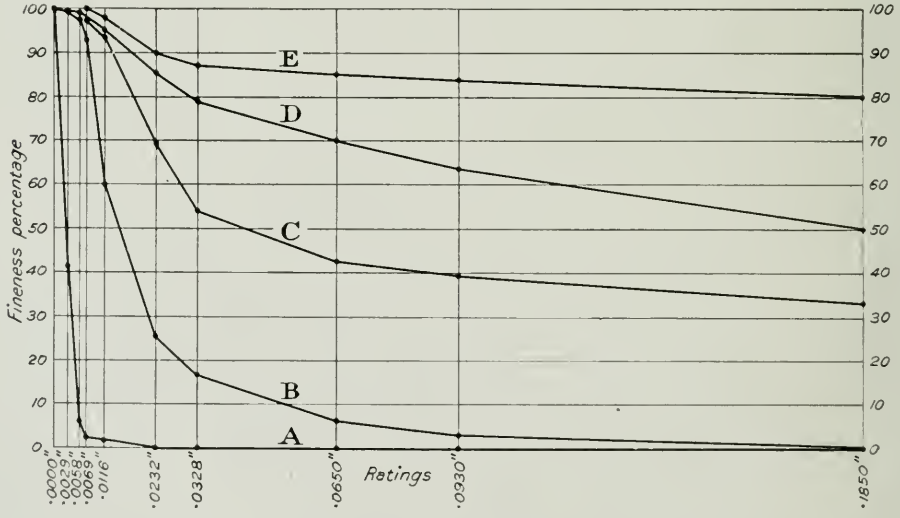

Fig. 2—Diagram of granular metric analyses of five different sands and gravels of various percentages of fineness.

of the material; for fine sand this area is large, it is smaller for medium sand, and becomes very small for coarse gravel. This system of geometrical representation (fig. 2) has been applied to the five granular metric analyses given above. All the curves start from the point 100 on the axis of the ordinates; their general shape is parabolic except near the axis of the ordinate, where there is an inversion point on the curves.

The maximum difference between the quantities of material remaining on two alternate sieves such as 4 and 10, 8 and 20, 48 and 100, etc., is a measure of the uniformity of the clastic material. This difference is called the *coefficient of uniformity*. The number of the intermediate sieve in our scale of sieves represents the *grade* of the tested material.

Shape.—The shape of the component fragments is also variable in character. In sands the grains are rounded or angular. If the latter shape is quite common to all the grains, they constitute a sharp sand, much appreciated for building purposes. The difference between a sharp and a rounded sand can be tested under the microscope: it can also be easily ascertained by rolling the grains between the tips of the fingers. For gravels a similar distinction may be established: the component pebbles are spherical, elliptical, flat, disc-like or angular: hence such terms as round gravel and sharp gravel.

Physical Properties

The following physical properties are of interest in the study of sand and gravel: Specific gravity, Percentage of voids, Permeability, Absorption, Moisture, Percentage of silt, Cementing value, Bonding power.

Specific gravity.—The specific gravity of a sand or gravel may be considered in two different ways. The *apparent* specific gravity of a sand or gravel is the weight of a certain volume of the material, divided by the weight of an equal volume of water. The *real* specific gravity is, on the other hand, the average specific gravity of the fragments composing the material. The real specific gravity is always higher than the apparent specific gravity.

The apparent specific gravity is easily obtained by weighing a known volume of the sand or gravel and dividing the weight of the material by the weight of an equal volume of water. The material should be shaken down as much as possible in order to reduce the volume of voids to the minimum.

Determination of specific gravity.—The real specific gravity of sand may be determined with a glass vessel having a narrow neck with a reference mark. This is filled to the reference mark with water at a standard temperature. A weighed quantity of the sand under examination is poured into the vessel. The pouring should be very slow in order to prevent air bubbles being carried down with the sand. The displaced water is poured from the vessel until the level is the same as before, viz., at the reference mark. This water has been displaced by the sand, and its weight divided into the weight of the sand gives the real specific gravity of the sand. The formula for calculating the specific gravity by this method is as follows:

If "W" is the weight of the sand poured into the flask, and,
"W_1" is the weight of the displaced water, then

$$\text{Real specific gravity} = \frac{W}{W_1}.$$

In order to eliminate the air bubbles, the flask containing the sample and water may be placed in an iron cylinder and connected with an air pump to produce a vacuum.

For very coarse gravels a similar method should be applied, the sample having a weight of at least 1,000 grams. The apparatus should be of metal and of a corresponding size.

Weight per cubic foot.—This value is easily obtained from the apparent specific gravity Da, and is equal to 62,484 × Da lbs.

In referring to the weight per cubic foot the physical condition of the material should be referred to as loose or compact, and the degree of moisture should be stated as wet, moist or dry. Compact sand or gravel may be described as material that has been deposited in a bin from a height or has been shaken down in a vessel.

Percentage of voids.—If Dr is the real specific gravity, and Da the apparent specific gravity, the percentage of voids (v) may be calculated from the following formula:

$$v=100\ \frac{Dr-Da}{Dr}$$

It has been found that in the case of a uniform sand made of equal spherical grains the voids vary between 25.95 and 47.64 per cent., depending upon the arrangement of the grains. In the measurement of sands containing grains of different size and of angular shape the percentage of voids was very often nearly 37 per cent., the average of the two extreme theoretical values. The voids are lower in sands made of grains varying in size than in uniform material: they are also lower in coarse sands than in fine-grained ones.

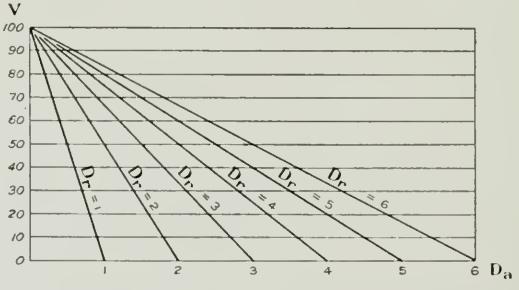

Fig 3—Diagram of the percentage of voids (v), in function of the apparent specific gravity (Da) for different values of the real specific gravity (Dr).

Diagrams of percentage of voids in functions of the apparent specific gravity, for given values of real specific gravity are straight lines. If the apparent specific gravities are taken as abscissae, and the percentage of voids as ordinates, all the diagrams corresponding to different values of Dr converge at the point v=100 on the axis of the ordinates. The diagram for which Dr=A cuts the axis of the abscissae at a point for which Da=A (fig. 3).

The percentage of voids may be directly measured by using a beaker perforated on the side to admit a siphon, as shown in figure 4.

The beaker is filled with water, and the glass tubing acting as a siphon brings the water in the beaker to a constant level. A volume V of the material to be tested in then poured into the beaker driving a volume V of water out of the beaker through the siphon.

The percentage of voids (v) is given by the following equation:

$$v = 100\frac{V-V'}{V}$$

Permeability.—While the porosity of a sand or gravel is expressed by the amount of pore space or the percentage of voids, the permeability is the quality possessed by certain of these materials to permit an easy passage of liquids or gases. This quality depends partly upon the percentage of voids, but also upon the size of the voids. It is a very important factor in moulding sands and filtering sands. If the pores are small, capillarity and friction prevent or lessen the passage of liquids and gases. Coarse material is therefore more permeable than fine grained. Sands uniform in size are also more permeable than sands of a similar grade, made up of various sizes.

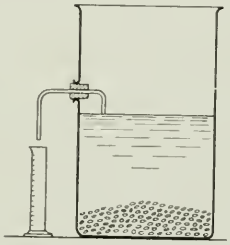

Fig. 4—Beaker for the measurement of the percentage of voids in sands or gravels.

Permeability may be directly measured by filling a tube with a given volume of the material to be tested, and measuring the time necessary for a given quantity of water or air to pass through the material.

Absorption.—On putting a sample of dry gravel or sand into water, a certain amount of water is absorbed by the fragments. The amount depends principally upon the nature of the fragments. The absorption for quartz grains is negligible, but for cleavable minerals such as calcite and feldspar it is larger, and for fragments of porous rocks, such as sandstone, still greater. To measure the percentage of absorption, a sample of the material is placed in water for about one hour; it is then removed and spread on blotting paper and when surface dry, weighed in this state. The sample is then dried over a hot plate to a constant weight. The difference in weight between the surface-dry material and the dried material, multiplied by 100 and divided by the weight of the dried material, gives the percentage of absorption.

Moisture.—The percentage of moisture is obtained by weighing a sample of the material in its natural state—as it comes out of the pit or ready for use—and the sample thoroughly dried. The difference of the two weighings, multiplied by 100, and divided by the weight of the dried sample, represents the percentage of moisture.

Percentage of silt.—This is measured as follows: A weighed sample of the dry material, about 200 grams, is placed in a broad glass tube provided with perforated stoppers and tubes at each end. The tube is placed in the vertical position and a current of water allowed to enter through the bottom and pass away through the top. The tube is shaken from time to time, and the current of water continued till it carries no more silt and is perfectly clear when coming out of the tube. The material is then again dried till the weight is constant. The difference between the weights of the material before and after the experiment, multiplied by 100, and divided by the weight of the sample before the experiment, gives the percentage of silt.

Value in concrete.—Sand is mixed with Portland cement in the proportion, 1 part cement to 3 or 4 parts of sand. The mortar obtained is moulded into briquettes used for tension or compression tests with the ordinary testing machines.

Screened gravel or crushed stone is mixed with sand and Portland cement to produce concrete. The three materials are mixed in different proportions taking into account the amount of sand contained in the gravel. Some proportions in use are:

Cement	Sand	Gravel or Crushed Stone
1	2	3
1	2	4
1	3	6

The concrete is moulded into cubes to be tested for crushing strength.

Bonding Power.—The bonding power is the property of certain sand grains to adhere more or less to one another. It is an essential quality of a moulding sand, as it permits the sand to retain in all its details the form of the mould. A dry sand made of quartz grains only, does not exhibit any bonding power. This quality is principally due to the presence of some cementing material coating the grains. This material is generally clay, though the amount of ferric hydroxide and of moisture also affects the bonding power. It is generally increased by tamping the sand, thus reducing the percentage of voids and allowing more grains to touch one another and to cement together. This property is sometimes artificially increased in foundries, by adding molasses, clay or linseed oil to the sand.

The bonding power is measured by moulding the sand into briquettes, and testing their tensile strength in a specially devised testing machine. The ordinary cement testing machine is not suitable, as it is not sufficiently delicate for testing materials of such low tensile strength.

Composition

The composition of sands and gravels may be determined either by a chemical analysis or by mineralogical examination. For most of their uses the chemical composition is of little interest, as there is no simple relation between it and the physical properties of the material. For some purposes, such as for glass-making and in chemical or metallurgical industries, knowledge of the chemical composition is absolutely necessary. A chemical analysis of sand is a long and tedious operation, and little work of this kind has been done on the several varieties of sand.

As in igneous rocks, there is a relation between the chemical and the mineralogical composition of a sand. Analyses of sand may be calculated in terms of a certain number of standard minerals, by a method similar to the one used for the quantitative classification of igneous rocks (Cross, Iddings, Pirson and Washington: "The Quantitative Classification of Igneous Rocks." University of Chicago Press, 1903). The standard minerals used in the calculations are: Calcite ($CaCO_3$), Orthoclase ($K_2O.Al_2O_3.6SiO_2$), Albite ($Na_2O.Al_2O_3.6SiO_2$), Anorthite ($CaO.Al_2O_3.2SiO_2$), Corundum (Al_2O_3), Magnetite ($Fe_2O_3.FeO$), Wollastonite ($CaO.SiO_2$), Grünerite ($FeO.SiO_2$), Enstatite ($MgO.SiO_2$), Quartz (SiO_2) and Water (H_2O).

An example of such a calculation follows:

SHARP SAND FROM PIT OF JOHN CREEPER, BELLEVILLE, HASTINGS CO.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	CO_2	H_2O	Total
Percentage	55.46	9.99	0.81	1.58	14.88	1.29	2.04	2.62	11.04	0.43	100.14
Molecular Number	.924	.098	.005	.022	.266	.032	.021	.042	.251	.024	
	.....	.....	.....	.....	251	.....	.....	.....	251	.....	Calcite ..25.10
	126	21	.....	.....	.....	.....	21	.....	.....	.....	Orthoclase..11.68
	252	42	.....	.....	.....	.....	.....	42	.....	.....	Albite...22.01
	30	15	.....	.....	15	.....	.....	.....	.....	.....	Anorthite.... 4.17
	.....	20	.....	.....	.....	.....	.....	.....	.....	.....	Corundum 2.04
	.....	.....	5	5	.....	.....	.....	.....	.....	.....	Magnetite 1.16
	32	.....	.....	.....	.....	32	.....	.....	.....	.....	Enstatite 3.20
	17	.....	.....	17	.....	.....	.....	.....	.....	.....	Grünerite 2.24
	467	.....	.....	.....	.....	.....	.....	.....	.....	.....	Quartz ..28.02
	.....	.....	.....	.....	.....	.....	.....	.....	.....	24	Water... 0.43
											Total ..100.05

This calculated mineralogical composition is called the *norm,* and should not be taken for the mode or actual mineral composition of the examined sample. A large amount of calcite in the norm indicates a sand originating from the decay of limestone. The feldspars are usually present as calculated. Corundum is a very rare constituent of sands, but its presence in the norm may be due to the presence of kaolinite or clay in the sand. Magnetite is very common as small grains in sands. Wollastonite, enstatite and grünerite are the three simplest mineral molecules entering in the composition of micas, amphiboles and pyroxenes; their amount in the norm gives an indication as to the quantity of the complex iron, magnesium and calcium bearing silicates present in the sand. Quartz is the more common constituent of sands; its percentage in the

norm is sometimes much lower than the percentage of silica in the chemical analysis, since a large amount of silica may be combined with oxides to form silicates.

A mineralogical investigation is more easily made; the sand or gravel may be examined with the naked eye, or in greater detail under the microscope. The use of heavy solutions allows a separation by gravity of the fragments, which is very useful when the material is made of two or three minerals of very different specific gravity.

Sands are in general composed principally of quartz, which frequently accounts for more than 70 per cent. of the total; the other minerals found in Ontario sands being: feldspar, mica, amphibole, pyroxene, calcite, magnetite, garnet, zircon, kaolin, and limonite. In coarse sands rock fragments are found just as in gravel. A great number of gravels, principally in the southern part of the Province along the Great Lakes, are composed of limestone pebbles with a small proportion of igneous and metamorphic rocks. The limestone accounts very often for more than 75 per cent. of the total, but in some cases the gravel is of sandstone or quartzite pebbles. Slate pebbles should not be present in a good gravel, as the cleavage and softness of slate are a source of weakness either for roadwork or concrete. On roads the slate is very soon pulverized to dust, and in concrete beams it may reduce the compressive strength 75 per cent. In the districts of Ontario near the border of the Laurentian granitic belt, the gravels are composed of igneous rocks as the predominant material.

Origin of Sands and Gravels

Sands and gravels are produced by the weathering of other rocks; and may remain in place or be transported by the action of water or wind. As a rule, the material remaining in place is the most angular, the transported material being well rounded, although some of its grains may be broken into conchoidal chips.

The principal sand and gravel deposits met in southern and eastern Ontario belong to one or other of the following types:

(1) Residuary Sands and Gravels

These represent the products of weathering of rocks which remained at their original place of formation. At the early stages of the decomposition the result is a residuary gravel, but later on each rock fragment is decomposed into smaller pieces and so on until each individual mineral grain is liberated. Of course the products more or less soluble are progressively washed away by percolating waters, and only very resistant minerals such as quartz remain as the final product of the disintegration. The grains are generally angular and the resulting sand sharp. Very often the quartz grains retain a coating of claylike material due to the decomposition of the silicates. The residuary sand generally contains about 70 per cent. of silica, and about 20 per cent. of alumina and iron oxides. The residuary deposits may be found in connection with siliceous limestones, sandstones or shales, and in such cases the original stratification may

be preserved during the weathering process. But generally these deposits are not stratified, especially when derived from igneous or metamorphic rocks. In southern Ontario some deposits of residuary sands overlie Laurentian granite.

(2) Talus Deposits of Sand and Gravel

During the weathering of rocky hills or cliffs the debris does not remain in place, but rolls down to the bottom of the cliffs where it accumulates and forms a talus deposit. This type of deposit is generally a sharp gravel containing fragments of variable size originating from the neighbouring rocks. The disintegration of the large fragments leads to the formation of a sand whose grains roll farther down the slope, forming a talus under the natural angle of repose. Such deposits are found in southern Ontario along important ridges such as

Fig. 5—Alluvial deposit on shore of Toronto Island.

the Niagara escarpment and the granitic ridge marking the southern border of the Laurentian plateau. They do not show any stratification and are generally very narrow.

(3) Alluvial Deposits

The most important of these deposits in Ontario are those formed in connection with the history of the Great Lakes (figs. 5 and 6). Extending over hundreds of miles, these ancient beaches constitute extensive reserves of sand and gravel. The grains are generally rounded and are composed of different minerals, quartz being the most abundant in the sands. The nature of the gravel pebbles depends upon the constitution of the neighbouring rocks. The alluvial deposits always exhibit stratification (fig. 6).

Alluvial deposits are formed not only on the shores of seas or lakes but also in the valleys of rivers: by repeated freshets, the solid particles carried by the water are spread over the soil and increase the alluvial deposit little by little (fig. 7). If the river passes through a lake the basin of the lake may in time be filled by the silt brought in by the river. A similar process goes on where the river flows into the sea: as the current becomes slower, the solid particles are deposited and so begins the building up of a delta.

Alluvial deposits of sand and gravel are most numerous in southern and eastern Ontario, and are generally well suited for building material.

Fig. 6—Lake alluvial deposit of gravel. Note stratification.

(4) Glacial Deposits

These deposits have been brought into their present position by the action of the ice-sheet which covered, in Pleistocene time, the greater part of eastern Canada. Most of the material in these deposits consists of fragments of northern rocks. The material is very often a mixture of sand, gravel and clay, and is known as glacial drift. It is sometimes heaped up in small conical hills or drumlins, as well as in moraines of various types: ground moraine, marginal moraine, and terminal moraine.

These deposits rarely furnish pure sand or gravel.

(5) Dune Sand

This sand is carried by the action of wind. The sand resulting from the decomposition of sandstone, granite or other rocks containing quartz may be carried by the wind for long distances. The deposits formed in this way are

as a rule unstratified; while the grains are more rounded than in other types of sand. Dunes are generally grouped together in long ridges of hills at right angles to the prevalent direction of the wind.

The most important dune formation in southeastern Ontario lies on the western coast of Prince Edward county (fig. 8). Enormous reserves of sand have been accumulated there between Wellington and Sandbanks; this aeolian formation is gradually advancing inland.

Uses of Sands and Gravels

The principal uses of sand and gravel may be enumerated under the following headings:

Concrete or building sand.
Concrete gravel.
Road gravel.
Moulding sand.
Glass sand.
Filtering sand.
Locomotive sand.

Fig. 7—River alluvial deposit. Valley covered by gravel, east of Kincardine.

Concrete or Building Sand

A good concrete or building sand should consist principally of quartz grains ree from loam, dust or vegetable matter. The grains should be angular and sharp; he material should pass a one-quarter inch mesh, but not more than 15 per ent. of the grains should pass the 50-mesh sieve, and not more than 2 per cent. hould pass the 100-mesh sieve.

The tensile strength of a briquette made by mixing the sand with Portland cement in the ratio 3 of sand to 1 of cement must be similar to the tensile strength of a briquette prepared under the same conditions with standard Ottawa sand.[1]

[1] This material occurs as a large deposit of silica sand at Ottawa, Illinois, U.S. Owing to the uniformity of size and composition of this sand it is used as a standard specification sand all over this continent. The grains pass a 20-mesh and are retained on a 30-mesh screen.

There are plenty of reserves of good building sand in Ontario, but in the neighbourhood of the large towns the deposits are more or less exhausted; builders in Toronto, for instance, are forced to bring considerable quantities of sand from pits located 30 and 40 miles away.

Concrete Gravel

The best gravel for concrete is composed chiefly of very fine pebbles, approaching pea-gravel in size. The material should be retained on a ¼-inch screen and pass completely through a 1½-inch screen. The pebbles should be principally hard limestone, sandstone, or granite; pebbles of shale or other fissile rocks should not be present. The proportion of silt ought also to be a minimum.

Fig. 8—Sand dunes near Wellington, Prince Edward county.

Road Gravel

This is a coarser grade than concrete gravel, and is usually the run of the pit. Pebbles larger than two inches in diameter should be discarded or may be used in the foundation of the road, but on the upper part of the roadbed it is advisable to place finer material. The presence of shale and loam in the gravel is objectionable. Such gravel should be carefully avoided, since these materials are quickly crushed to dust by the traffic.

Moulding Sand

The essential qualities of moulding sand are its permeability to gases and vapours, its bonding power by which the sand holds the form in which it has been moulded, and its infusibility at high temperatures. The most important of these qualities is the bonding power, which depends more or less upon the amount of clay, iron hydroxide and water mixed with the sand, but the relation

of the chemical composition of the sand to the bonding power is not as yet well understood. All the methods proposed to get quantitative figures on the bonding are only approximate. A foundry foreman usually determines the bonding power by squeezing a sample in his hand, and noting whether it holds its shape.

For a long period nearly all the moulding sand used in Canada was imported into this country from the United States. There are, however, several important deposits of moulding sand in Ontario, occurring in very similar conditions to those found in the states of New Jersey and New York. In Ontario, the moulding sand appears generally as a deposit under the superficial soil, when this soil comes in contact with an underlying sand formation (fig. 9). The moulding sand, which around Hamilton and Toronto seldom exceeds more than two or three feet in thickness, seems to owe its origin to the circulation of water and to

Fig. 9—Surface modification in sand formation by the roots of trees, St. John's Cemetery, Kingston Road (York county).

the action of vegetable and other organic life. It occurs in very different grades of fineness, the coarsest material being used for large and rough castings, while very fine moulding sand is used for brass and copper castings. As this is a high-priced sand which can be exploited without expensive equipment, there is a possibility of developing a considerable industry in this material for Canada.

Glass Sand

Sand for glass manufacture should be as pure as possible, and approach in composition the standard of pure silica. The constituent grains should therefore be essentially of white quartz; all other minerals, and especially the ferro-magnesian ones, must be considered as impurities. The presence of iron in the sand imparts to the glass a peculiar green colour, and seriously impairs the quality. Various processes have been proposed to neutralize this green-iron

coloration through the addition of manganese, nickel oxide or selenium. Certain iron-bearing minerals can be removed from sand by magnetic separation. As a rule a good glass sand should contain more than 99 per cent. of silica and less than 0.2 per cent. of iron oxide. A small percentage of alumina and alkalies in the form of feldspar grains is valuable in a glass sand, as it reduces the quantity of these materials to be added to the batch.

Following is the analysis [1] of a typical New Jersey glass sand:—

	Per cent.		Per cent.
SiO_2	99.40	CaO	0.008
Fe_2O_3	0.0058	MgO	0.012
Al_2O_3	0.2752	Organic matter and moisture	0.231
TiO_2	0.0737		
		Total	100.0057

The shape of the grains is without importance for glass sand. Sometimes this pure sand is obtained directly from the pits. In other cases it is prepared by crushing a more or less disintegrated sandstone, as at the plant of the Oneida Lime and Sand Co., near Hagersville.

The size should be a good medium; the majority of the grains should pass a 30-mesh sieve and remain on a 100-mesh sieve. The coefficient of uniformity ought to be greater than 50, and the grade between 5 and 7.

The presence of grains smaller than 0.1 mm. causes the formation of "seed" in the glass.

Filtering Sand

Filtration sand or gravel must be very clean, and contain only a small amount of silt, loam, or other impurities. The fineness of the material depends upon the kind of filtration to be done. Washed material is always to be preferred for this purpose to the ordinary pit material.

Locomotive Sand

Sand for this purpose should consist of hard grains; it is used to prevent the slipping of engines and cars on railway tracks. It must be very clean and well washed material, in order to prevent the stopping of the sand pipe.

The finer grades of gravel are used on roofs. Sand is used as an abrasive for cutting and polishing stones; also as a filler for paper, as filling material for fireproof safes, for the making of sand paper, as a raw material in pottery and brick manufacture. The production of white sand-lime brick requires a good, clean and sharp sand, quite free of alkalies.

Distribution of Sand and Gravel in Ontario

Sand and gravel deposits are very numerous in older, or southern and eastern Ontario, and may be found in every county (Map No. 27*b*). The lake shores sometimes present very good material, and they are at some places extensively dredged. Above Sault Ste. Marie, gravel is pumped out of Lake Superior. Along the Lake

[1] The Mineral Industry, 1913. Silica, p. 667. Analysis by R. B. Gage, N.J. Geol. Survey.

Huron and the Georgian Bay shores mention should be made of large deposits of sand and gravel near Collingwood (fig. 10) in Nottawasaga bay, at Owen Sound, Southampton, Port Elgin, Kincardine, Goderich and Sarnia. Sand and gravel are dredged out of the St. Clair river and sold principally at Detroit. Among the deposits located along the Canadian Shore of Lake Erie, the principal ones are the bars near Point Pelee and Pelee Island, in Essex county. Other deposits of some importance are located near Point aux Pins, at Rondeau Park; at Long Point Bay; south of Simcoe; on the bar formed in the lake at the mouth of the Grand River (Haldimand county); and at the eastern end of Lake Erie, where a large sand deposit is found in the township of Humberstone south of Sherks, the sandhills extending probably as far west as Port Colborne.

Fig. 10—Gravel formation, east of Collingwood (Simcoe county).

There is a gravel bar at the mouth of the Niagara river in Lake Ontario, which was used in building the new Welland canal. No commercial deposits occur on the shore of Lake Ontario between Port Dalhousie and Burlington, but at the latter place there is a sand bar controlled by the Burlington Beach Commission.

There is nothing of commercial value from Hamilton to Toronto, where some sand and gravel is found along the beach and on the Island at the entrance of Toronto harbour. Gravel and sand are at present being dredged from the lake at Dunbarton, Whitby, Port Hope and Frenchman's bay. Large deposits are found on the shore of Lake Ontario in Prince Edward county, near Wellington and Picton. Some sand and gravel is to be noticed along the Bay of Quinte, east of Belleville. A gravel bar is forming at the northeast extremity of Amherst island in Addington county, and another on the south shore of Simcoe island in Frontenac. Some gravel and sand is taken out of the St. Lawrence, near Brockville, and out of the Ottawa river, at Ottawa.

The largest supply of sand and gravel, however, comes from pits located on ridges or terraces marking the shores of extinct lakes or old rivers.

It has been considered useful to trace the general approximate position of the ancient shore lines of Lake Iroquois and Lake Algonquin in Ontario (Map No. 27*b*), as a great number of sand and gravel deposits are located along these shore lines. The map was compiled from the work of A. P. Coleman, T. W. Goldthwait, Frank B. Taylor, Frank Leverett, and W. A. Johnston. One of the best marked ridges of this kind is the old shore of Lake Iroquois. A series of deposits is found along this line in Ontario, from Lewiston on the Niagara river, westward to Hamilton and Dundas, and from Dundas northeastward to Trenton. (*See* map of Lake Iroquois, by A. P. Coleman, in Thirteenth Report of the Ontario Bureau of Mines, 1904). The average distance between the old shore line of Lake Iroquois and the present shore line of Lake Ontario is five miles. On the north shore of Lake Ontario east of Toronto, the Canadian Northern railway follows quite continuously the shore line of Lake Iroquois.

Old shore lines are not so definitely marked north of the present shore of Lake Erie, although a certain number of sand and gravel deposits at about five miles from the shore belong very probably to the shore of the lake when the level was 50 or 100 feet higher.

A certain number of deposits located on a ridge about 10 to 15 miles from the present shore line of Lake Huron, indicate the old shore line of glacial Lake Algonquin; it passes through Copleston and Petrolia, Parkhill, and Exeter.

Most of the sand and gravel deposits in southern and eastern Ontario are thus very closely connected with the geological history of the Great Lakes. Just as the present shore lines do not show continuous deposits of sand or gravel, the old shore lines are marked by isolated zones or areas more or less parallel to the present shore lines.

In the following description, the several counties and districts are examined in alphabetical order, and typical deposits are described in each.

Algoma District

In this very large district only the area in close vicinity to Sault Ste. Marie was visited. Three groups of geological formations appear there: (1) The pre-Cambrian granite which outcrops about five miles north of the St. Mary river at the Sault, forming a ridge very characteristic of the local topography. (2) The Ordovician sandstones of Potsdam age. (3) The Recent and Glacial formation made of gravel, sand and clay, covering the greater part of the area between the granitic ridge and the St. Mary river. This formation, principally of clay, shows a variable thickness, from 10 feet to more than 271 feet, as indicated by the records of well borings. The principal pits are indicated on a sketch map of the area around Sault Ste. Marie (fig. 11).

I. J. Downey and Sons, East Street, Sault Ste. Marie.—Some gravel is dredged for this firm at Point aux Pins, five or six miles above the Sault, by Capt. McLean, who possesses a dredging outfit.

To accompany Report by A. LEDOUX, in Vol 27, Part II, of the Ontario Bureau of Mines, 1918.

Base map from Railway Map of Canada, Dept. of Interior, Ottawa. Scale: 35 miles to the inch.

Map No. 27b.

SAND AND GRAVEL PRODUCING AREAS IN SOUTHERN ONTARIO

I. J. Downey and Sons also have a gravel pit on the Canadian Pacific railway at mile 123, about ten miles east of the Sault, and just east of Garden river. Pebbles and boulders up to 6 feet in diameter were observed (fig. 12), which are principally composed of granite or gneiss.

Fig. 11—Map showing location of the principal sand and gravel deposits in the vicinity of Sault Ste. Marie, district of Algoma. 1. I. J. Downey, Garden River. 2. McPhail & Wright, Steelton. 3. McPhail & Wright, Bellevue. 4. Lyons Fuel Co., Searchmont. 5. Algoma Central Railway Co. 6. Municipality of Tarentorus tp. 7. Everett, Sault. 8. The "Landslide." 9. Campment D'Ours island.

Other pebbles are of diabase or of some metamorphic rocks with pegmatite veins, or of quartzite. The pebbles are angular, and the gravel is used for ballast. The section of the pit is about 150 feet high and between 1,200 and 1,500 feet wide. There are special tracks. In August, 1917, the pit was idle; the output had been reduced in 1916, when it was about 460 carloads, averaging about 28 yards per car, or a total of 13,000 cubic yards. The production in 1912 was eight or nine cars a day, and for the whole year between 50,000 and 60,000 cubic yards. This gravel was sold at an average price of 80 cents on dock, and delivered in town at $1.50 a cubic yard.

McPhail and Wright.—This Sault St. Marie firm owns a sandpit at mile 3 on the Algoma Central railway. It is located three miles north of Steelton, and about 300 yards northwest of the city graveyard. The worked excavation is about 150 by 150 by 35 feet; 12 acres of the deposit having been already excavated. The deposit extends as far as half a mile to the northwest, and the company owns 40 acres more of it on which test holes have given between 35 and 40 feet of sand. This

Fig. 12—Downey gravel pit, Garden River (Algoma).

sand shows generally an oblique stratification; it becomes a little coarser in the upper parts of the pit to the north. This coarse part is used for locomotive sand. The following is a granular metric analysis of this variety:—

Mesh.	4	8	10	20	28	48	80	100	200
Percentage retained ..	0.55	2.80	4.20	9.60	17.20	55.00	86.65	95.90	99.65

Per cent. of fineness, 58.72.

The average sand is used for building purposes and for making cores, but about 90 per cent. is used by the steel plants at the Sault for their blast furnaces. The ordinary building sand gave the following results by granular metric analysis:

Mesh	4	8	10	20	28	48	80	100	200
Percentage retained.	0.0	1.30	2.50	8.85	19.25	75.65	96.30	98.65	99.30

Per cent. of fineness	55.35	Apparent specific gravity	1.525
Percentage of absorption	4.9	Weight in lbs. per cubic foot	95.288
Percentage of moisture	1.73	Percentage of voids	43.5
Real specific gravity	2.701		

At the southern part of the sandpit, the surface is a little lower, and the sand near the surface a little browner and shows some bonding power, so that it is used for moulding work. There is a railway siding into the pit. Most of the work is done by hand. On an average three men are employed about 175 days a year. Two 40-ton cars are loaded daily, though the number of cars shipped in 1916 was only 163. The material is sold at $1.00 per yard delivered at the Sault, from which must be deducted the freight charge of 35 cents a yard.

Quartz Quarry.—McPhail and Wright have also a quarry of pure quartz rock located at Bellevue, at mile 21, on the Algoma Central railway. They ship from 6,000 to 8,000 tons a year of this material, which is principally used by the Algoma Steel plant. The rock has a faint pink tinge. It sells at $1.25 to $1.50 per ton f.o.b. at the quarry. The freight costs about 40 cents per ton. Mr. Warden, the chemist of the Algoma Steel Corporation, has kindly contributed the following chemical analysis of this rock:—

	Per cent.		Per cent.
SiO_2	97.25	MgO	0.16
Fe_2O_3	1.86	H_2O	...
Al_2O_3	0.25		
CaO	0.10		99.62

Lyons Fuel Co., Steelton.—This company owns a gravel pit near Searchmont, at mile 34 on the Algoma Central Railway. The output in 1916 was 29,556 yards; 15,000 yards being sold at 65 cents and the balance at 85 cents a yard. This price includes 45 cents freight rate. The bulk of the output was used for the construction of the new power canal, and the remainder for general work.

Algoma Central and Hudson Bay Railway Co.—This company has a gravel pit located along the railway near the fifth base line in the township of Tarentorus. The excavation is very large, being about 300 yards long, 40 yards wide, and probably 40 feet deep. The Root river passes through the excavation and disappears partially underground in the gravel. This gravel extends as far south as the springs of Coldwater creek, and constitutes a natural filter for the supplying of pure water in the Coldwater creek ravine. The gravel of the pit was mostly used for ballast.

The company owns another gravel pit on lots 8 and 9, in the sixth concession of the township of Hodgins. At the bottom of this pit there is a bed of sand, probably 20 or 30 feet deep, which is said to underlie the whole territory.[1] The sand which is covered by 20 to 25 feet of gravel and boulders is fine grained, as shown by the following granular metric analysis:—

Mesh	4	8	10	20	28	48	80	100	200
Percentage retained...	0.0	0.0	0.0	0.0	tr.	5.05	49.35	74.05	94.35

Per cent. of fineness	75.24
Co-efficient of uniformity	69.00
Grade	No. 7

The chemical analysis by W. K. McNeill, Provincial Assayer, of the sand from this deposit is as follows:—

	Per cent.		Per cent.
Silica	73.38	Potash	1.78
Alumina	12.14	Soda	3.58
Ferric Oxide	2.00	Water	0.73
Ferrous Oxide	2.71	Carbon dioxide	0.52
Lime	3.00		
Magnesia	0.24	Total	100.08

This sand contains too high a percentage of alumina to make a good glass sand.

The norm calculated from the chemical composition is as follows:—

		Per cent.		Per cent.
Calcite		1.20	Enstatite	0.60
Feldspars ..52.63	Orthoclase	10.56	Grünerite	3.30
	Albite	30.39	Quartz	38.70
	Anorthite	11.68	Water	00.73
Magnetite		3.02		
				100.20

The large proportion of acid feldspars and quartz plainly indicates the granitic origin of this material.

Under the microscope the sand is seen to be composed of angular grains, which for the most part are quartz, though there are also grains of tourmaline, mica and feldspar. Minerals rich in iron are absent or rare.

Tarentorus Municipal Pit.—This pit is located on the eastern side of the Great Northern road in the southwest quarter of section 29. It has produced gravel and sand for the past five years, the material being used for building purposes and road work. The ratepayers are allowed to take the gravel to put on the roads near their lots. At present the pit is a circular excavation about 100 feet in diameter and 3 to 7 feet deep. Most of the material is brown in color. The brown sand contains considerable gravel, and is of inferior quality owing to the presence of much loam. Some layers of gravel are black, the pebbles being cemented by some black material.

[1] C. H. E. Rounthwaite, engineer of the Algoma Central railway.

Everett Gravel Pit.—This pit is located about 100 yards north of the Tarentorus pit and along the west side of the Great Northern road. The size of the excavation is about 150 by 100 by 10 feet. The pit was previously owned by the city of Sault Ste. Marie. At present it is idle, and the greater part is flooded. The gravel is a little coarser than that in the Tarentorus pit. The two pits mark a gravel ridge striking across the road at N. 60° W. This ridge is from 50 to 75 yards wide, covering an area of about five acres, the average depth being 7 feet.

Fig. 13—Landslide along the Garden River road, near the falls of Silver creek, Sault Ste. Marie (Algoma).

Landslide Gravel.—A large amount of gravel is available at a place called "The Landslide," located about five miles north of Sault Ste. Marie, near Silver Creek falls (fig. 13). This gravel is principally composed of granitic material. A granite ridge is located a little north of the "Landslide," and makes at this point a great bend in a southeasterly direction.

Campment D'Ours Glass Sand.—White sand said to be suitable for glass-making is available on Campment D'Ours island. This island, 1,240 acres in area, is located in the St. Joseph channel, Lake Huron, near Desbarats station, on the Canadian Pacific railway. The post-office is Maclennan.

Brant County

The city of Brantford for the most part is built on beds of gravel. The principal operators of sand and gravel pits in the city of Brantford are given in the following list:—

Name and address.	Location of pit.	Nature of material.
Brantford Lands Co., Brantford	Erie Ave.	Sand and gravel.
J. B. Stratford, Ava Rd., Brantford	W. Brantford	Gravel.
J. M. Callock, 53 Palmerston Ave., Brantford	Baldwin Ave.	Gravel.
City of Brantford Corporation, City Hall	St. Paul Ave.	Sand.

Brantford Lands Co. Pit.—This pit is located on the western side of Erie Ave., in the southeastern part of Brantford. The excavation measures at present 200 yards by 150 yards by 10 feet, and has been worked for ten years. The deposit consists of gravel and sand, the pebbles being principally limestone or dolomite, with some fragments of granitic and metamorphosed rocks. About 75 per cent. of the material is limestone. The average pebbles are not larger than two inches. A granular metric analysis of this gravel follows:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained ...	54.75	60.95	63.80	72.95	84.15	95.40	98.35	99.15	99.65

Per cent. of fineness: 18.98.

The output is about 10,000 cubic yards per year, the gravel being sold at $0.40 a load of 1.25 yards. There remains a reserve of about 600 feet by 45 feet by 10 feet, a supply for two years. The material is of good quality for concrete, sidewalks and road-building. On the exhaustion of this pit other pits will probably be opened in the northwest part of the city.

The Cockshutt Plough Co. secured in 1916 about a thousand yards of moulding sand on lot No. 1, on the north side of the Brantford-Paris road, owned by Messrs. M. McEwen, J. Watkins, and T. W. Henderson, of Brantford. This farm has an area of 175 acres and is completely covered by about 1½ to 2 feet of moulding sand under 6 inches of sandy loam. This moulding sand is sold at 75 cents per yard, two yards making a load of average size.

Brantford City Pit.—This is located on St. Paul Avenue, opposite the hospital, and consists of two excavations, the eastern one being 200 by 200 by 12 feet in size, the western one 200 by 100 by 15 feet. They are separated by a sand ridge 200 feet long and 30 feet wide, this ridge being the principal reserve in sight. The sand is rather sharp, and contains a small proportion of pebbles not larger than 0.5 inch. The granular metric analysis gave the following results for this sand:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained ...	12.25	13.45	14.35	19.60	40.00	95.10	98.65	99.20	99.60

Per cent. of fineness 45.31
Percentage of absorption 0.30
Percentage of moisture 0.10
Real specific gravity 2.762
Apparent specific gravity 1.59
Weight in lbs. per cubic foot ... 99.35
Percentage of voids 42.4

There is about one foot of moulding sand at the top of this deposit.

Other Deposits.—Besides the Brantford deposits there are sand and gravel deposits in Brant county at Paris, belonging to Jos. R. Moyle, and at Mt. Pleasant belonging to the National Sand and Material Co., Ltd., Welland. There is gravel on a number of other farms near Paris, but most of the deposits have not been opened.

Bruce County

In this county the principal sand and gravel deposits are to be found along the shore of Lake Huron. Good sand and gravel beaches are found at Southampton, Port Elgin, and Kincardine. In the last-named town, the beach material is used for roads, concrete buildings, and sidewalks.

This beach extends about 40 miles north of Kincardine and about 30 miles to the south. Along the shore outcrops of limestone, gravel and sand appear. The gravel is composed principally of limestone pebbles with some fragments of granitic, igneous and metamorphosed rocks. The pebbles are various in size, some being as large as 4 inches in diameter. The gravel extends in some places as far as 1½ miles from the lake shore, and is about 5 feet deep, being most abundant and best washed near the shore.

Granular metric analyses of Kincardine gravel and sand:—

Gravel.

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	71.05	87.30	91.55	95.55	96.10	97.90	99.75	99.95	100.00

Per cent. of fineness 6.76

Sand.

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	4.05	5.25	5.50	5.70	6.00	30.35	95.65	99.10	99.25

Sand Analysis.

Percentage of absorption 0.21
Percentage of moisture 0.0
Real specific gravity 2.673
Apparent specific gravity 1.61
Weight in lbs. per cubic foot 100.59
Percentage of voids 39.4

Carleton County

The principal market for sand and gravel in this county is Ottawa. Large quantities of these materials are dredged in the Ottawa river, near Kettle island, MacLaren island, and Duck island, east of Ottawa. All these islands are sandy with a rocky base. The average depth of the sand is three to four feet.

The principal deposits of sand and gravel near Ottawa are indicated in fig. 14.

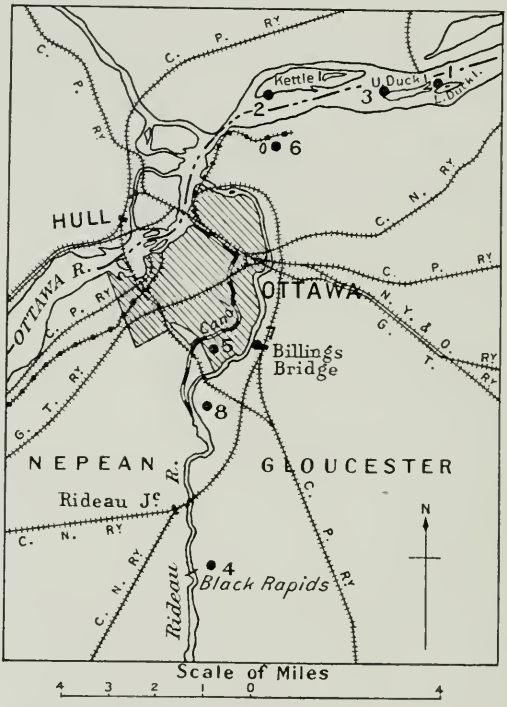

Fig. 14—Sketch map showing deposits of sand and gravel near Ottawa. 1. Beaton and Johnson. 2, 3, 4. Rideau Canal Supply Co. 5. Carnochan. 6. Chas. Keefer. 7. R. A. Nesbitt.

Beaton and Johnson, Ottawa.—This firm have a dredging outfit in the channel of the Ottawa river, near Duck island. In 1916 their total output was one hundred large loads of 120 yards per load, which sold on the wharf at 45 cents per yard. This sand is sharp and of very good quality, and is used for building purposes. The results of a granular metric analysis of this Ottawa sand follow:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.0	0.0	0.10	6.30	34.80	83.60	92.95	97.20	99.60

Per cent. of fineness	53.94	Apparent specific gravity	1.56
Percentage of absorption	0.33	Weight in lbs. per cubic foot	97.48
Percentage of moisture	0.27	Percentage of voids	40.6
Real specific gravity	2.626		

The Rideau Canal Supply Co.—This company also dredges a large quantity of sand near Duck and Kettle islands. In 1916 its output was 19,260 yards, which was sold for delivery in Ottawa at 90 cents a yard. It is all used for cement work.

The same company has a sandpit near Black rapids, on the Rideau river, about five miles south of Ottawa. The pit is 60 feet deep and covers an area of one acre; there are 14 acres in reserve. The output in 1916 was 9,493 yards. For delivery in Ottawa the price is 90 cents per yard. This sand is used for building purposes, and asphalt work.

Carnochan's Sand and Gravel Pit.—Mr. Carnochan owns a pit in the southwestern part of Ottawa, between Hopewell avenue and Glen street, west of Leonard street. This pit is 60 feet by 100 feet in area, with an average depth of 10 feet and a maximum depth of 20 feet. It was opened twenty years ago. The upper 12 feet are gravel, with the largest pebbles on top. In general these pebbles are not larger than four inches, and are principally limestone, angular in shape. Eight feet of good sharp sand, mixed with small pebbles, underlies the gravel. The stratification is oblique and irregular, and indicates a delta formation. The deposit is not nearly exhausted, but the pit cannot well be worked much longer owing to near-by buildings. The present output is about 200 yards per year, and sells at an average price of 70 cents a yard at the pit.

Rockcliffe Sand and Gravel Pit.—Ch. Keefer, 310 Bank Building, Sparks street, Ottawa, kindly furnished the following information about the deposit he works in the northeastern part of the city, known as Rockcliffe sand and gravel pit. The location of this deposit is Block 15 B of lot 2, junction gore of the township of Gloucester, near the shore of Hemlock lake. The whole area is 34 acres, of which 17 are sand and gravel. The area worked up to the present time covers 4½ acres, the average depth of the workings being 15 feet. The pit supplies principally sharp sand, which has been extensively used for concrete work in Ottawa. The output in 1916 was 2,854 yards of sand, which sold at 25 cents a yard at the pit. The following tests were made by the testing laboratory of the Public Works Department at Ottawa, in December, 1913.

Granular metric analysis:—

Mesh	4	8	10	20	30	50	80	100	200
Per cent. retained	0.	0.	0.	6.2	42.9	75.8	93.6	95.2	98.6

Per cent. of fineness, 54.19

N.B.—This value of the per cent. of fineness should be used for an approximate comparison only with other values given in this report, as the analysis was made by means of a different series of sieves.

Real specific gravity	2.64
Apparent specific gravity	1.45
Weight in lbs. per cubic foot	90.60
Percentage of voids	45.3

Tensile strength—Mixture 1: 3

7 days	Standard sand	306 pounds
	Rockcliffe sand	322 "
28 days	Standard sand	356 "
	Rockcliffe sand	362 "

The bottom of Hemlock lake is composed of sand, and large reserves could be worked by a pumping dredge.

R. A. Nesbitt's Sand and Gravel Pit (south of Ottawa).—This property is located east of the Rideau river a little north of Billings Bridge. There are two pits of 250 feet in diameter near the River road, Stanley road and Billings avenue. The whole block is about 3 acres in area. The greatest part of the deposit is worked out, and the wall is close to buildings. This wall is 14 feet high; the upper five feet are loamy and mixed with large stones without value. Then comes one foot of sharp sand and under it three feet of gravel, which is mixed with at least 60 per cent. of sand. The pebbles are between two and four inches in size, and about 90 per cent. of them are limestone, the remainder being primarily granite and gneiss. Under the gravel is two feet of sharp sand, and as one goes deeper this sand becomes much finer. This material was sold at 75 cents a yard for the gravel, and 50 cents a yard for the sand at the pit.

J. Blair's Pit.—There are some deposits of sand southeast of Arnprior, in the northwest corner of the county of Carleton. One of the most important is J. Blair's pit, in the township of Fitzroy, lot 22, fourth concession. The pit is at present 200 by 60 by 25 feet. The upper three feet are loam, and then there are 22 feet of gravel. The pit is located three miles from Arnprior, near the G. T. Ry. tracks. The G. T. Ry. Co. estimates that there are 15 million yards in reserve on an area of about eight acres. The gravel is composed of rounded pebbles of limestone and granite and other materials averaging from one to two inches in diameter. At the north end of the pit sharp sand of good quality overlies the gravel, the contact dipping to the north at an angle of 40°. This sand is not worked at the present time, but the gravel is used for roadwork and ballast. The approximate output in 1916 was 500 yards, sold at 25 cents per load of 1½ cubic yards.

Granular metric analysis of gravel from Blair's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	97.15	97.50	97.60	97.85	98.05	98.75	99.25	99.50	99.80

Per cent. of fineness 1.84
Coefficient of uniformity 97.50
Grade ..... No. 1

Patterson's Gravel Pit.—Mr. Patterson, of Arnprior, owns a pit in Fitzroy township, lot 27 in the third concession, which is 300 by 100 by 15 feet and contains layers of coarse sand, and pea gravel showing sometimes auto-cementing properties. Mixtures of 1 to 7 make good concrete with this gravel. The output in 1916 was 500 yards, which sold at 20 cents per ward. There is a reserve of two acres of gravel on this property.

Dundas County

In this county the principal deposits are located in the townships of Williamsburg and Matilda, around Williamsburg, Morrisburg and Iroquois (fig 15).

Styles' Sandpit.—On lot 16, first concession, township of Williamsburg. This pit lies about four miles east from Morrisburg station, north of the Grand Trunk railway and half a mile north of the St. Lawrence river. The sand in this region forms a ridge of drumloid hills. The upper two feet of the deposit are loamy and the material is not used. Under the loam are 11 ft. of good sharp sand used for building concrete and sidewalks. The principal hill worked at present is 100 yards long and 30 yards wide. The ridge extends to Morrisburg, but the sand becomes too fine in size and of poor quality toward the west. The

Fig. 15—Map showing location of sand and gravel deposits in the southern part of Dundas county. Sand pits:—(1) Styles, (17) Armstrong. Gravel pits:—(2) Shanette, (3) Coghlan, (4) Froats, (5) Hall, (6) Colquhoun, (7) D. Gillard, (8) Carlough, (9) Casselman, (10) Whittaker, (11) Weaver, (12) and (13) McMillan, (14) Merkeley, (15) Shaver, (16) Brouse, (18) Beckstead.

output of this pit is about 100 cubic yards a year, and is sold at 50 cents a yard at the pit and $1.75 delivered at Morrisburg. There is an available reserve of at least 10,000 cubic yards.

Shanette's and Coghlan's Gravel Pits.—The former is on lot 34, concession four, and the latter on the same lot in concession three, Williamsburg township. These pits are located on both sides of the third concession road and west of the road from Morrisburg to Williamsburg. The gravel strata are 10 feet higher than the level of this road, the upper part being of large pebbles

or boulders, generally of a dark blue crystalline limestone. In the lower part, smaller pebbles become more abundant, the gravel being more sandy at the bottom. The pebbles average three inches in size, and they consist predominantly of Silurian limestone containing numerous fossil shells. Some granitic and metamorphic pebbles are also present. The Shanette pit is an excavation 150 by 30 by 8 feet. The Coghlan pit is newly opened, the gravel being exposed for a length of 120 feet. These deposits are part of a forest-covered ridge and contain a reserve of 2½ acres.

Granular metric analysis of Shanette's pit gravel:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	67.15	73.25	76.85	87.05	93.15	98.75	99.55	99.70	99.85

Per cent. of fineness 11.63

N.B.—The pebbles remaining on the 4-mesh sieve include 46 per cent. larger than 1 inch, and 21.15 per cent. smaller than 1 inch, or total 67.15 per cent.

Harry Froat's Gravel Pit.—On lot 29, concession four, Williamsburg. This deposit is nearly exhausted, and comprises several small pits lying under water. There remains in reserve an area of about 50 yards by 20 yards, the gravel having a depth of nearly 5 feet. This material is used as cement gravel, and sells at 50 cents a yard at the pit.

Hall's Gravel Pit.—On lot 26, concession four, Williamsburg, there is an excavation of 150 by 30 by 3 feet. The pebbles, which are predominantly of limestone with some granite, sandstone, and quartz, are large in size and mixed with boulders.

R. Colquhoun's Gravel Pit.—On lot 23, concession four, Williamsburg. The pit is at present 100 by 50 by 4 feet in size. It lies behind the farm buildings at the top of a ridge, on which there remains half an acre in reserve. Most of the material is subangular limestone gravel, with numerous boulders. The lower part of the pit is more sandy.

David Gillard's Gravel Pit.—On lot 21, concession four, Williamsburg. This pit, which has been idle for some years, is 100 by 40 by 5 feet in extent, with a great variety of pebbles of limestone and igneous rocks. The reserve covers about one acre.

Jacob Carlough's Gravel Pit.—On west half lot 28, concession five, Williamsburg. The excavation, which is 200 by 100 by 6 feet, is located on a hill running in northeast-southwest direction. The average pebbles are 3 inches in diameter, but towards the east the pebbles are larger and interspersed with boulders. No gravel has been sold from this pit for several years.

Miss Casselman's Gravel Pit.—On lot 27, concession five, Williamsburg. The excavation is 200 by 100 by 4 feet. The pebbles are angular and of different sizes down to 4 inches in diameter; they consist of limestone, metamorphosed and igneous rocks, and become more sandy in the lower parts. The material is used as concrete and road gravel.

H. M. Whittaker's Gravel Pit.—On lot 31, concession four, Williamsburg. This pit is located about three-quarters of a mile north of Williamsburg, on a ridge running approximately in a north and south direction. The deposit has

Fig. 16—Whittaker pit, showing inclined stratification, Williamsburg, Dundas county.

been worked from the north, on an area of 500 yards by 40 yards, the wall becoming higher at the southern part, where it is 15 feet high. The stratification is oblique (fig. 16) the layers dipping at an angle of 30°. The seams are of different grades and about one foot thick; there is a little loam and about 40 per cent. of the deposit is sand, a portion being blue and calcareous. There are some large boulders, but most of the gravel consists of angular pebbles of limestone and granite, not exceeding two inches in diameter. Eruptive and metamorphosed rocks are more abundant among the large stones than among the

small pebbles, where limestone is predominant. This gravel is at present used for concrete making in a bank building at Williamsburg. One team hauls about 10 loads a day from the pit to Williamsburg. The available reserve extends over four acres south of the present pit.

Thomas Weaver's Gravel Pit.—On lot 30, concession six, Williamsburg. This pit is located on the northeast prolongation of the Whittaker pit, and was closed two years ago. The ridge extends still farther in a northeast direction, but is all under crop.

Arthur McMillan's Gravel Pit.—On lot 18, concession seven, Williamsburg. This pit is located about one mile east of Elma, on both sides of a north and south road to Dunbar and Chesterville. The gravel ridge has a direction N.60°E. The gravel is of good quality, consisting principally of limestone with a certain amount of igneous material. The average pebbles are 2 to 3 inches in diameter; large pebbles being scarce. The excavation on the west side of the road is 300 by 90 by 6 feet; that on the eastern side 600 by 200 by 4 feet. The pits are completely covered with vegetation and have not been worked for several years. The reserve extends over 4 acres.

Charles Merkeley's Gravel Pit.—On lot 2, concession five, township of Matilda. This pit is located near the road from Williamsburg to Dundela. About 600 by 100 by 4 feet have been taken out, but work has been discontinued for several years, although there seems to be an equal reserve lying north of the pit, under the orchard. The work was to start again this year, as one-quarter of an acre of this property was sold to the council of Matilda township.

Edgar J. Shaver's Gravel Pit.—On west half lot 20, concession two, Matilda township. This pit is southwest of the Iroquois graveyard. It is about 100 by 50 by 7 feet. There are large stones at the top, but the lower 5 feet are of good limestone gravel, the pebbles being on an average 1 to 2 inches in diameter. This material sold this year at 75 cents a yard.

Brouse's Gravel Pit.—On lot 21, concession two, Matilda. The excavation has the form of a circle, 100 feet in diameter. There are 6 feet of grey sand at the top on the eastern side, and under it the gravel formation is 10 feet thick. The gravel is similar to that from the Shaver pit, the pebbles being a little larger.

Armstrong's Sand Pit.—On lot 19, concession two, Matilda. The pit is 200 by 100 by 12 feet in size, and is not worked at present. There is a reserve of good building sand about 200 by 100 by 6 feet in sight. Some large stones, probably rejected from the gravel, have been dumped in the centre of the pit.

Granular metric analysis of Armstrong sand:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.0	0.35	0.50	1.30	3.65	33.50	70.90	86.90	97.50

Per cent. of fineness 67.27
Real specific gravity 2.713
Apparent specific gravity 1.54
Weight in lbs. per cubic foot.... 96.23
Percentage of voids 43.2

Albert Beckstead's Gravel Pit.—On lots 3 and 4 in concession one, Williamsburg township. The excavation is now 150 yards by 20 yards by 2 yards (average). On the top of the ridge there is about 1½ feet of loam and under it 8 feet of gravel. There is a reserve of about 75 yards by 20 yards by 2 yards. The gravel is composed of angular pebbles, principally limestone. These vary in size from one-tenth to five inches, while some boulders reach 1 foot in diameter. The proportion of sand is small. This gravel was used for concrete making in the Morrisburg canal, as well as for bridges, houses and road building. It was sold at 50 cents a yard at the pit and $2.00 for delivery in Morrisburg. The output is at present small, although in some years it reached 1,000 yards.

Durham County

In this county there are some sand and gravel deposits around Port Hope and Bowmanville.

Thos. A. G. Bray's Gravel Pit, Port Hope.—On lot 2, concession four, township of Hope. The excavation is 150 by 150 by 4 feet, the available reserve covering an area of 7 acres. The top of the deposit is covered by boulder clay under which there is a coarse gravel consisting of large pebbles and then about 5 inches of limestone gravel, mixed with about 20 per cent. of sandy material.

Granular metric analysis of limestone gravel:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	80.00	83.40	84.65	87.00	89.45	98.65	99.80	100.00	100.00

Per cent. of fineness, 8.56.

The 80 per cent. remaining on the 4-mesh sieve is composed of 48.05 per cent. pebbles larger than 2 inches, 17.85 per cent. nut pebbles about 1 inch in diameter, and 14.10 per cent. pea gravel smaller than 1 inch.

Hiram Walker's Gravel Pit, Port Hope.—On lot 18, concession three, Hope. The pit lies on top of a rounded hill. The present excavation is 300 by 150 by 4 feet in size, but gravel was found to a depth of 8 feet. The available reserve is approximately 1,200 by 150 by 4 feet. The pit is located one-quarter of a mile south of the Canadian Northern[1] Railway tracks. The gravel is composed of limestone pebbles which at the top are large, but smaller near the bottom, where they are mixed with a certain amount of sand. This deposit extends in a northerly direction through concession four, where it has been worked largely by the C. N. R. for ballast.

There are several other gravel deposits at an average distance of six miles north from the Lake Ontario shore at Port Hope. These deposits belong to the old Lake Iroquois beach, and are abundant near Quay. This shore line of Lake Iroquois is very well marked through the whole of Durham county, and the

[1] Now, since change to Government ownership, called Canadian National Railways. See also on subsequent pages.

C. N. R. tracks follow more or less this line of gravel deposits. Some deposits are located outside of this general ridge, this being the case for the gravel pits lying north of Port Hope and Charlecotte.[1]

Gravel pits, Hope township.—On lot 9, concession two, behind the Pomeroy house is a circular pit 100 feet in diameter by 12 feet in depth. The gravel is very coarse at the top and finer near the bottom; it is principally composed of limestone. Fifty yards west of this pit is a second circular pit about 200 feet in diameter and of similar character. A little farther north on the west side of the road there is a third pit worked for road gravel by P. Sleemon, of Port Hope. The excavation is 200 by 150 by 12 feet in size. At the time of the writer's visit, it was worked by 9 men and 5 teams. The gravel was sold at 15 cents a yard.

Fig. 17—Inland dune, invading cultural areas, north of Charlecotte, Durham county.

Sandy formation between Charlecotte and Clarke.—This formation extends along the road between Charlecotte, Hope township, and Clarke, in the township of Clarke, as a ridge of sandy hills. It lies in concession two of Hope township and concessions one and two of Clarke township. The reserves are very large, and at some places gravel pits have been opened, but the greatest proportion of the deposit is a fine ferruginous sand which was used for making mortar. This sand, as it contains almost no bonding material and is unprotected by vegetation, is transported by the wind over the adjacent agricultural lands, forming inland dunes (fig. 17).

Similar formations occur around Kendal and Orono.

Sand and gravel on shore of Lake Ontario at Port Hope.—This beach is composed principally of recent sand, which has been shipped by the carload for building purposes. The beach is about 60 yards wide near the station, where there is also some fine limestone gravel. Farther west the beach narrows to 3 or 4 yards, and the gravel becomes coarser, certain pebbles being 4 inches in diameter.

[1] See L. Reinecke, Road Material Surveys in 1914, Geological Survey of Canada, Memoir 85, pp. 141 *et seq.*

Granular metric analysis of lake shore sand, Port Hope:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.0	0.0	tr.	0.10	0.35	17.55	87.15	97.25	99.75

Per cent. of fineness 66.43
Apparent specific gravity 1.62
Real specific gravity 2.706
Weight in lbs. per cubic foot 101.22
Percentage of voids 40.1

Township of Darlington.—In the immediate neighbourhood of Bowmanville there are no important deposits of sand or gravel, but farther north there are some deposits near the C. N. R. tracks along the old Lake Iroquois beach principally near Tyrone station. The pits are generally small, and the deposits not very deep. The gravel contains about 75 per cent. of limestone pebbles. Beds of good sharp sand alternate sometimes with the gravel beds. Great quantities of this gravel were used for ballast, but there remains yet along this old shore line in the township of Darlington an available reserve of more than one million cubic yards.

Elgin County

There are several deposits round St. Thomas and Port Stanley. M. U. Ferguson, the city engineer of St. Thomas, kindly furnished information and assistance respecting these deposits. Gravel is very abundant in the city of St. Thomas, where it occurs in Kettle creek as river-washed gravel, and there are also pit deposits. The creek gravel is good concrete gravel, but, lacking bonding material, is not suited to road making. The pit gravel contains enough clay to make good road gravel, but is not good concrete material.

Ponsford's Gravel and Sand Pit, St. Thomas.—This pit is in the township of Yarmouth, on lot 17, concession eight. The excavation is about 500 by 250 by 20 feet; there are about 12 to 14 feet of gravel on the top and 6 to 8 feet of sand at the bottom. There is at least an area of 50 acres in reserve. The upper part of the deposit consists of alternate layers of gravel of various coarseness: the pebbles range in size up to 4 inches in diameter. Limestone is predominant, and accounts for 60 per cent. of the whole material, the remainder being granite, gneiss, etc. Some parts of the fine material are sharp and contain no clay; other parts nearer the surface are mixed with clay. The sand is screened and used in the manufacture of silica bricks. The output of this pit in 1916 was 2,700 loads (about 4,000 yards) of gravel, which sold at 40 cents a load.

Granular metric analysis:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	5.5	8.6	10.8	16.4	21.85	49.00	84.45	96.75	99.45

Per cent. of fineness 56.35
Real specific gravity 2.774
Apparent specific gravity 1.69
Weight in lbs. per cubic foot 105.59
Percentage of voids 39.1

City of St. Thomas Pit.—This pit is located behind the city park and supplies gravel and sand. The pebbles are not larger than half an inch in diameter. It makes a good pea gravel in macadam roads as a binder between larger pebbles. The sand is sharp and used for mortar making. The output in 1916 was 2,700 yards.

Granular metric analysis of gravel:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	24.60	34.45	39.75	50.25	59.50	86.20	96.10	97.40	98.30

Per cent. of fineness, 34.83.

Axford's Pit.—This pit is located southwest of the city pit, and the material is coarser, there being less sand and more gravel, the latter of good quality for concrete. The wall of the pit is 15 feet high and the reserve covers 40 acres.

Gravel within the city limits of St. Thomas.—In excavating for the construction of sewers and waterworks in St. Thomas, 3 or 4 feet of gravel of good quality were found underlying the whole city.

Sand deposit at Port Stanley.—On both sides of the Kettle valley running into Lake Erie, there are very high ridges made of silt and sand lying on a blue clay. The contact between the two formations is about at the lake level, and constitutes a line of weakness along which the clay is washed away so that the overlying sand and silt crumbles down. The ridge is between 100 and 150 feet high. This process of undermining is going on steadily. The sand and silt are of little importance for economic purposes. A little garnet sand and some coarse and sharp building sand are found on the beach.

Essex County

The most important deposits in this county (fig. 18) and among the largest in all Ontario are on the sand and gravel bars in Lake Erie near Point Pelee and Pelee island. There are some other gravel deposits near Leamington, and along the electric railway between Leamington and Windsor, and also south of Windsor, near Ojibway. In many creeks running south and north through this county, the gravel accumulates in the bends. In the pits, gravel and sand generally occur in alternate layers and the gravel is very often sandy.

Point Pelee; Cadwell Dredging Co., Windsor.—This company owns eight dredges each carrying 75 carloads of gravel which can be loaded in two and a half hours. The output in 1917 from the opening of navigation till the end of August was 151 dredge loads.

Point Pelee forms a peninsula in the shape of an acute triangle, the centre of Pelee island lying about 12 miles south of the point. The peninsula is continuously reduced in size by the washing of the lake, and since 1913, 1,300 feet have been removed from the end of the Point. The life-saving station erected by the Dominion government in 1914, 200 feet from the eastern shore, is now

only 90 feet from the shore, and during strong gales the bottom of the boathouse is washed by the waves. In April, 1917, it was 800 feet north of the end of the end of the peninsula, but in August of the same year this distance was reduced to 500 feet.

The area worked by the Cadwell Dredging Co. extends as a bar to the west of the peninsula and stretches from three miles south of the point to two miles

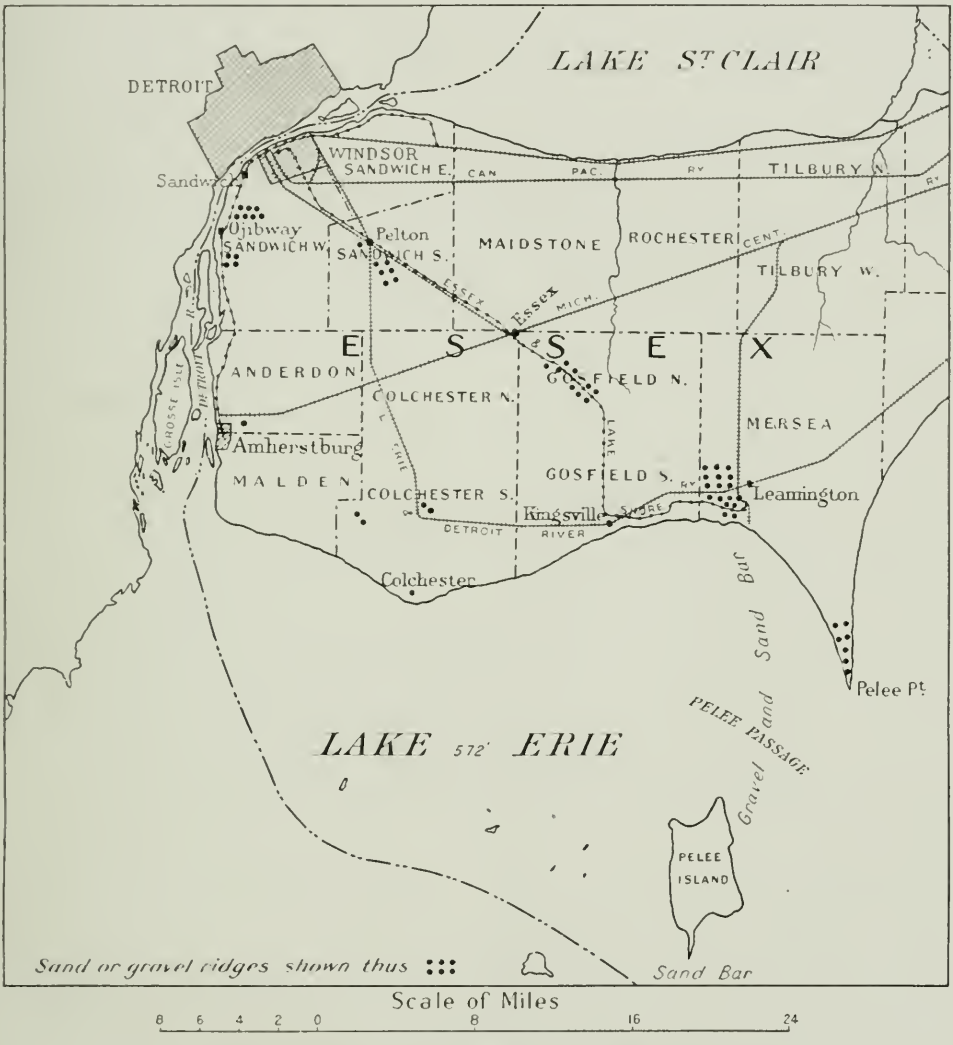

Fig. 18—Sand and gravel deposits in Essex county.

north. The dredges work about one mile from the point. South of Pelee island most of the gravel has been removed and only sand remains. It is very probable that the material taken from the bar south of Point Pelee is replaced by sand and gravel coming from the point. The peninsula is composed principally of gravel and sand layers which may be seen on both shores. Near the shore there

is a little zone, 20 feet wide, of sharp white sand, then comes a zone of gravel about 6 feet wide, and higher up a zone of very fine red garnetiferous sand. The southern part of the peninsula is covered by trees, mostly cedars. Three or four miles north of the point, where the peninsula becomes wider, sand dunes and sand ridges appear parallel to the western shore. They are about 10 feet high and consist of very white, fine sand. Farther north, the clay is nearer to the surface, and a clay dike has been built up to protect the farm land from incursions of the lake.

Nearer Leamington, sand and gravel are seen only in a narrow strip along the lake shore, the central part of the peninsula being composed mostly of silt and clay and constituting a fine agricultural region. Fifty rods from the shore the bottom of the lake is clay, the average depth being 15 feet. This clay also underlies the Pelee peninsula, and its gradual destruction is due to the washing away of the clay by a process similar to the one noticed at Port Stanley in Elgin county.

Most of the material dredged near Point Pelee goes to Cleveland, Toledo, and Detroit, in the United States.

Granlar metric analysis of white sand from shore at Point Pelee:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0	traces	0.50	10.60	37.30	83.65	98.05	99.65	99.80

Per cent. of fineness 52.27
Real specific gravity 2.664
Apparent specific gravity 1.667
Weight in lbs. per cubic foot ...104.161
Percentage of voids 37.4

Granular metric analysis of garnetiferous sand, Point Pelee:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0	0	0	0.20	1.05	40.05	92.60	99.20	99.90

Per cent. of fineness 63.00
Real specific gravity 3.403
Apparent specific gravity 2.165
Weight in lbs. per cubic foot ...135.278
Percentage of voids 36.4

Sandwich West township.—A ridge containing both sand and gravel is to be seen, south of Windsor, near Ojibway, on the property of the Canadian Steel Corporation, Ltd. This company expects to obtain 30,000 yards of sand from this deposit, though it may be necessary to remove an equal amount of overburden. There is about 8 to 10 feet of sand or gravel over the glacial boulder clay. This deposit was not being worked in August, 1917.

Frontenac County

This county is as a rule rocky, and sand deposits are not common. Some pits are located at Glenburnie and Cataraqui, and sand from the shore of Lake

Ontario is obtained, principally at Big Sandy bay, on the southwest corner of Wolfe island. Professor M. B. Baker suggested in a recent report[1] that the white lower beds of Potsdam sandstone might be valuable as a source of glass sand, as they are free from iron.

The Kingston Sand and Gravel Co., Raglan Road, Kingston.—The sand brought to Kingston by this company comes from pits located at Glenburnie, 7 miles north of Kingston. Between Kingston and Glenburnie, the north and south road runs through the Ordovician limestones. A sand ridge is situated east of Glenburnie in the direction of Maple Lawn. The pits are in concession

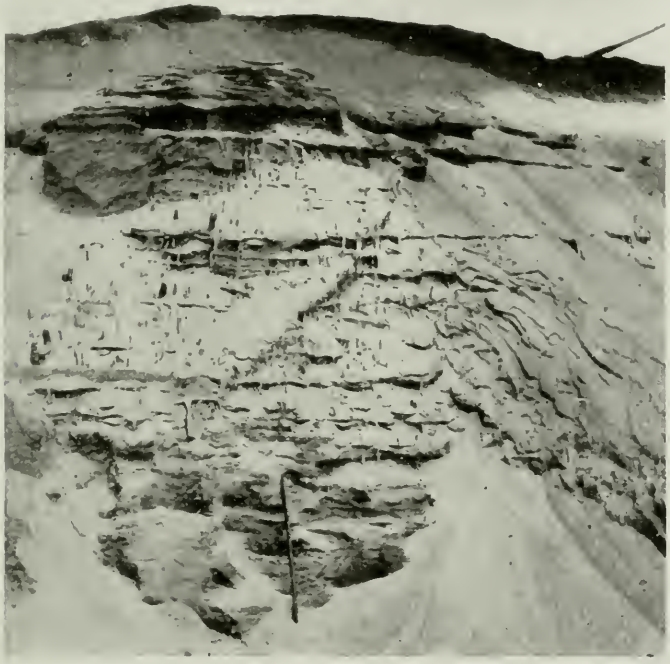

Fig. 19—Calcareous concretions in sand, Glenburnie, Frontenac county.

five, and between lots 30 and 35, township of Kingston, and are 20 to 30 feet deep. The three principal pits have areas of 100 by 150, 200 by 400, and 200 by 600 feet. The whole deposit is about 1,000 feet wide in a north and south direction, and more than 2,000 feet east and west. The sand is sharp and intermixed with small angular gravel of granitic nature. The upper part of the sand is brown for about 2 feet and shows some bonding power; below this part the colour becomes paler, and the greater part of the deposits consists of white sand. This sand contains quartz, feldspar and black mica among its grains, and some calcareous white concretions produced by the circulation of calcareous waters (fig. 19).

[1] 25th Annual Report, Part III, Ont. Bur. of Mines, 1916, The Geology of Kingston and Vicinity, p. 35.

These concretions are more abundant near the water level at the bottom of the pits.

Granular metric analysis of Glenburnie sand:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	1.55	2.40	2.80	3.85	5.70	37.95	77.30	90.95	98.45

Per cent. of fineness, 64.34.

Real specific gravity	2.700	Weight in lbs. per cubic foot ...	96.60
Apparent specific gravity	1.546	Percentage of voids	42.8

N.B.—The largest grains contain calcareous concretions.

The sand is hauled to Kingston in wagons drawn by four horses or by steam tractors. As the cost of transportation is high, it sells delivered at $1.40 per cu. yard. It is used principally for building purposes, but also for core-making at the locomotive works in Kingston.

Robert Harpell, Cataraqui.—On lot 16, concession three, Kingston township. This sand pit is part of a farm of 100 acres owned by Mr. Rixbridge, 4 miles northwest from Kingston. This sand sells at 40 cents a load of 3 cubic yards in the pit, or at $5.00 for a similar load delivered in Kingston.

Big Sandy Bay, Wolfe Island.—A little of this sand is brought by boats to Kingston; it is sharp, and suited for building purposes. It is proposed to load this sand by pumping it directly in the scows which bring it to Kingston.

Glengarry County

In the township of Kenyon, forming the northwest part of this county, there are some sand and gravel pits round Alexandria, Maxville and Dunvegan (fig. 20).

Most of the material is coarse gravel used for road work, and is not always of first quality. The gravel is very coarse, principally near the top, and contains many boulders, sometimes larger than one foot in diameter. In some pits more than 50 per cent. of the pebbles should be rejected on account of their size. Near the bottom the fragments are smaller, and the material may become a pea gravel or a coarse sand. The pebbles are mostly angular; from 70 to 90 per cent. are of limestone, but the gravel, considered as a whole, is rather sandy, and 50 per cent. of sand is not rare. The depth varies little from one pit to another, 12 feet being a good average. This material is sold as low as 10 cents a cubic yard. A list giving the names of the owners, location and size of the principal pits and their annual output follows:—

No.	Owner	Township, Con. and Lot	Size in feet	Output	Remarks
1	McKinnon, Alexandria ...	Lochiel III, 37 ..	75 by 50 by 12	.....	Ridge 200 by 300 ft. in area.
2	Wm. Metcalfe, Greenfield	Kenyon IX.	100 by 100 by 12	3,000 yds.	Reserves 500 by 100 by 12 ft.
3	Campbell, Dunvegan	Kenyon VIII, 17 ($W\frac{1}{2}$)	50 by 30 by 5	60 loads ..	Reserves 75 by 75 by 10 ft.
4	McLeod, Dunvegan	Kenyon IX, 19	90 by 30 by 4	.....	Two pits about 100 yards apart.
5	Hugh McIntosh, Dunvegan	Kenyon IX. 21 ..	50 by 15 by 8		
6	D. Kennedy, Maxville	Kenyon VIII, 36.	100 by 75 by 10	100 yds.	Reserves 50,000 cubic yds.
7	N. K. McLeod, Maxville.....	Kenyon VIII, 35.	60 by 60 by 20	.....	Reserves 25,000 cubic yds.
			60 by 15 by 4	.....	.....

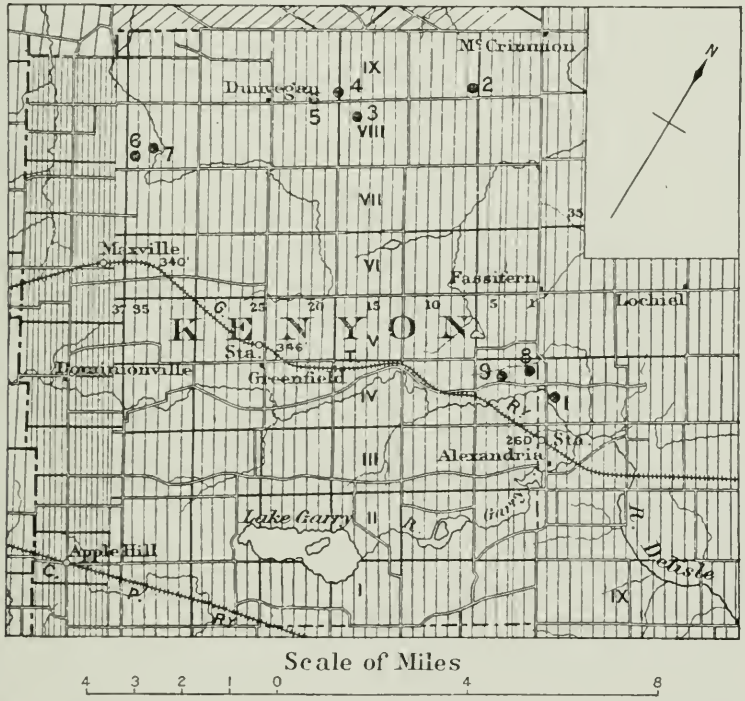

Fig. 20—Map of the township of Kenyon, Glengarry county, showing principal sand and gravel deposits. The numbers refer to the list given in the text.

Granular metric analysis of gravel in Wm. Metcalfe's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	82.65[1]	90.70	93.45	95.45	96.75	99.20	99.70	99.80	99.90

Percentage of fineness, 4.71.

[1] The 82.65 per cent. remaining on the 4-mesh sieve is made up of 54.65 per cent. larger than 1-inch pebbles and 28.00 per cent. between 1-inch and .185-inch.

Some of these gravel pits contain sand layers, and this is the case in the Kennedy pit, Maxville. At the bottom of this pit there are two feet of sharp black sand, very good for building purposes. Most of this sand is made of limestone grains.

Granular metric analysis of sand from D. Kennedy's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	6.80	14.30	21.65	58.35	85.25	97.95	98.70	98.80	98.90

Per cent. of fineness 35.5
Real specific gravity 2.722
Apparent specific gravity 1.706
Weight in lbs. per cubic foot ...106.60
Percentage of voids 37.3

Nap. Gauthier's Sand Pit, Alexandria (*No.* 8).—On lot 1, concession four, Kenyon township.—Excavation about 150 by 50 by 5 feet. The pit is not worked at present. The sand is fine and loamy near the top, and becomes coarser at the bottom. It is part of a ridge extending about a mile in an east and west direction and forming a watershed. Some sand of this formation was used for moulding purposes by the shell works in Alexandria.

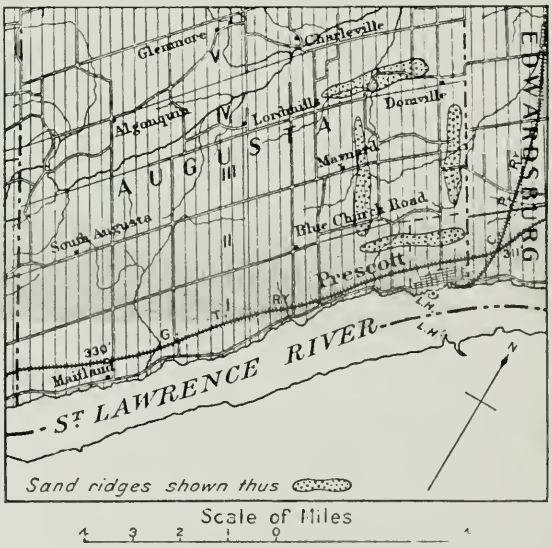

Fig. 21—Sand ridges north of Prescott, Grenville county.

McDonald's Sand Pit, near Alexandria (*No.* 9).—On the east half of lot 4, concession four, Kenyon. This belongs to the same formation as the preceding pit, and contains sand and gravel.

Grenville County

The deposits of sand north of Prescott belong to four ridges of sand dunes extending over concessions one, two and three, (fig. 21). Those dunes are advancing.

The length of the ridges is about one mile, with an average height of 15 feet and an average width of 250 feet. In concession one, this sand ridge

is about half a mile north of the Grand Trunk railway. It has a northwest direction, and extends over the cemetery and Prescott fair grounds. The sand is used for building. The excavations are generally refilled with sand a few days after they are opened. This sand is delivered in the town of Prescott for $1.00 a load of 1.5 cubic yards. There are two similar sand ridges but with a north and south direction, running through concession two, on both sides of the road to Domville. A fourth ridge with an east-west direction is located in concession four, on the grounds belonging to John Fell.

There is an important gravel ridge west of the sand dunes. The general direction of this ridge is N.30°E. Several pits have been opened, the average depth being 10 feet. The gravel contains a good proportion of sand; the pebbles range between 2 and 8 inches, in some places being very angular. About 50 per cent. consist of limestone, the remainder being eruptive and metamorphic rocks. This material is generally sold at 25 cents a yard at the pit. The following list gives the location, size and output of some of these gravel pits:

Owner	Township, Con., Lot	Size in feet	Output	Remarks
Corporation of Prescott	Augusta I, 8.	200 by 200 by 12	.....	Reserve: 1 acre.
Sterritt, Prescott	Augusta II, 10.	100 by 100 by 10	200 yd.	Pebbles smaller than in other pits.
Geo. W. Robinson, Prescott	Augusta II, 9.	200 by 200 by 10	.....	Reserve in sight: 300,000 cu. yds.
Wm. Robinson, Prescott	Augusta III 8.	.....	small	Large quantities available.

Granular metric analysis of gravel from Sterritt's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	77.00[1]	81.05	83.40	88.90	92.45	96.95	98.15	98.70	99.40

Percentage of fineness, 9.33.

Grey County

The deposits of sand and gravel in this county are few in number. The writer examined a few small sand pits near Meaford. Most of the area between Meaford and Owen Sound is occupied by limestone and glacial deposits.

The Sydenham river at Owen Sound runs through a very deep and steep valley, with three different terraces. Sand and clay are found on each of them. A hole dug in one of the streets of Owen Sound, near the river, shows 1 foot soil, followed by 5 feet of sand overlying clay. There is a large sand pit south of the town on the slope of the second terrace. The excavation made on the side of the hill is about 70 feet high and yields sand for building purposes. South of Owen Sound, at Inglis falls, there is some sand and gravel.

[1] Of the 77 per cent. remaining on the 4-mesh sieve, 52.35 per cent. were pebbles larger than 1 inch in diameter, and 24.65 pebbles smaller than 1 inch.

R. Smith's Sand Pit, Inglis Falls.—On lot 9, concession two, Derby township. The pit is about 100 feet in diameter and 25 feet deep. From testings the sand is known to extend 25 feet deeper. The deposit covers about 2½ acres, making an available reserve of about 200,000 cubic yards. In this pit there are alternate layers of gravel for rough-casting, filtering sand and plastering sand. Near this pit is another containing only gravel. The output in 1916, when the pits were owned by Mr. Neelands, was about 300 yards. Selling prices were 15 cents a yard for road gravel taken at the pit and $1.20 a yard for filtering sand delivered at the filtering plant of Owen Sound, located about one mile from the pit. Rockford station on the Owen Sound branch of the C. P. R. is about one mile east of the pit.

Granular metric analysis of plastering sand, R. Smith's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.30	0.80	1.35	3.90	11.80	71.00	91.65	95.85	98.20

Per cent. of fineness 58.35
Real specific gravity 2.732
Apparent specific gravity 1.575
Weight in lbs. per cubic foot.... 98.412
Percentage of voids 42.3

Granular metric analysis of filtering sand, R. Smith's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.65	3.05	7.95	36.60	60.60	90.90	97.20	98.50	99.35

Per cent. of fineness 45.02
Real specific gravity 2.687
Apparent specific gravity 1.539
Weight in lbs. per cubic foot 96.163
Percentage of voids 42.7

Haldimand County

There is a good sand beach near Port Maitland, on the shore of Lake Erie, at the mouth of the Grand river. The deposits are in the form of sand dunes extending for two miles along the lake shore and 300 to 500 feet inland. The deposit is from 12 to 15 feet thick and overlies the limestone. There are various grades of sands and gravels in the dunes. Near the surface the material is generally blown sand that could perhaps be used as an abrasive for cutting stones. Under one foot of this material the sand is coarser, and is used for building purposes. It passes gradually into a limestone gravel before the solid rock is reached. Dredging of gravel and sand is done in the river by a pumping dredge; Jos. Battle of Thorold operated such a dredge during 1916.

Numerous deposits of sand and gravel occur near the Grand river in the northwestern part of this county (fig. 22). They are mostly round Caledonia and seem to be ancient river terraces. The gravels are principally composed of pebbles, but contain a little shale. The sands are generally sharp and of good quality for building purposes.

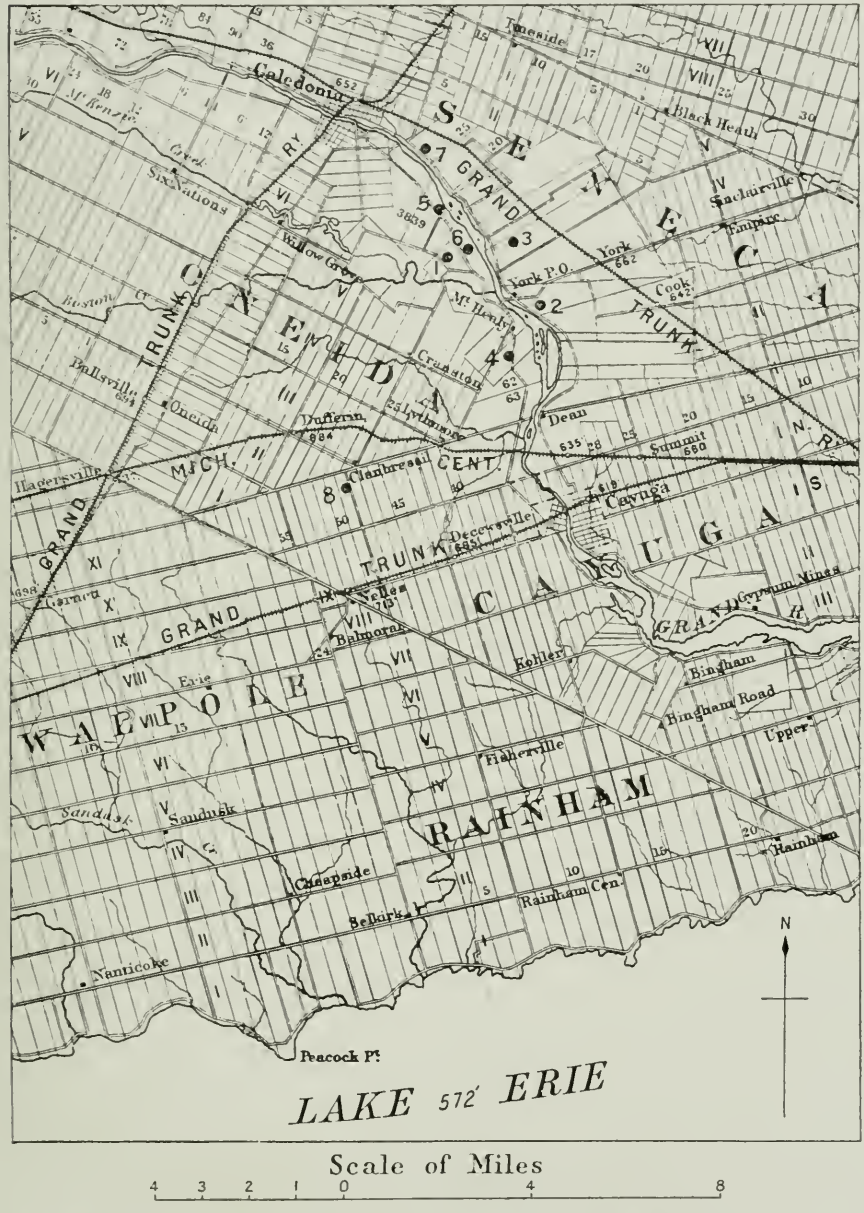

Fig. 22—Map showing sand and gravel pits along the Grand river, Haldimand county. The numbers refer to the list given in the text. No. 8 is the location of the Oneida Lime Co's. quarry.

The following list gives some information about the principal pits:

No.	Owner	Township	Size in feet	Product	Remarks
1	F. W. Foster, Caledonia	Oneida	60 by 60 by 7	Sand	Reserve: 4 acres, 2½ ft. of loam on top.
2	Isaac Gowland, York	Seneca	20 deep	Gravel	Idle; 5 ft. clay on top.
3	Robert Hamilton, Caledonia	Seneca	200 by 200 by 5	Gravel	Reserve: 10 acres, idle.
4	George Moore, Caledonia	Oneida	100 by 100 by 20	Gravel and sand	Only 1 ft. to be stripped.
5	Nicholas, Gideon, Caledonia	Oneida		Sand	Not working.
6	Arthur Smith, Caledonia	Oneida (Tiffany Block)	80 by 80 by 10	Sand 150 yd. per annum	Reserve: 5 acres. Sold at 40 cents a yd.
7	David Young, Caledonia	Seneca	2 acres 10 ft. deep	Gravel	Not working.

Oneida Lime Co., Limited.—An interesting deposit is the one worked by this company in Cayuga township, near Nelles Corners. The headquarters of the company are in Buffalo. This company quarries Oriskany sandstone of Devonian age, and by crushing this material obtains a very pure white sand used for glass making. After washing, this sand contains sometimes as much as 99.50 per cent. of pure silica. The works have been operating six years. The quarry in 1917 measured 300 by 100 by 12 feet. There is an old quarry to the west of the present one of double the size.

The Oriskany sandstone appears to form a small basin overlying the Salina limestone beds of Silurian age and covered by the Onondaga limestone. At the quarry the section is as follows:

Brown soil	4 to 6 inches.
Coarse sandstone	4 "
White and fine sandstone	3 feet.
Coarse sandstone	4 inches.
Ferruginous sandstone	6 "
Quartzitic sandstone	6 feet.
Dolomitic limestone	

The rock varies in grain and nature in a vertical as well as in a horizontal direction. At some places, the sandstone can be crushed to sand between the fingers; at other places, it is much more like a quartzite.

The Oneida Lime Co., Ltd., owns about 150 acres. To the east of its property and on the same outcrop, there is another property, 200 acres in size, belonging to the Consolidated Plate Glass Co.

The material from the quarry is washed and crushed to a coarse sand, composed principally of small grains, but containing also some fragments up to 8 mm. in diameter. In this state the sand is suitable for use in steel plants. To produce glass sand, the crushed material is passed through an 8-mesh screen and the oversize is recrushed. There were about 25 employees working for the greater part of the year. Some material is shipped during winter months from storage bins. The output for 1916 was about 15,000 tons and sold at $1.50 to $1.70 a ton.

Granular metric analysis of glass-making sand. Grade No. 6, The Oneida Lime Co.:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.00	1.20	2.50	7.60	17.70	64.80	93.60	98.15	99.40

Per cent. of fineness	57.23	Apparent specific gravity	1.64
Coefficient of uniformity	75.90	Weight in lbs. per cubic foot	102.474
Real specific gravity	2.612	Percentage of voids	37.2

Two analyses made at the Babcock Testing Laboratory, Buffalo, of crushed sandstone from this quarry follow:

	Old Quarry.	New Quarry.
Moisture	0.00	0.00
Loss on ignition	0.93	0.13
Iron (metallic?)	1.63	1.48
Al_2O_3	trace	trace
CaO	1.55	0.71
MgO	0.30	trace
S	0.11	0.08
SiO_2 (by difference)	95.48	97.60
Total	100.00	100.00

It is probable that the iron considered as metallic is in the form of magnetite (Fe_3O_4).

Following is a chemical analysis of this sand, ready for glass works, by W. K. McNeill:—

	Per cent.		Per cent.
Silica	96.54	Alkalies	0.94
Alumina	0.96	Carbon dioxide	0.59
Ferric oxide	trace	Water	0.15
Ferrous oxide	nil		
Lime	0.90		100.08

The figures of the three analyses are very similar, and confirm the value of this material for chemical industries. This sand would be suitable for the manufacture of silica brick. Similar materials are used for such purposes in France. From a recent note of M. Philippon [1] the following results are taken:

(1) The crushing strength of the bricks after drying and burning is greater the more finely the quartz grains are pulverized.

(2) All the quartz tested will give strong bricks if it is sufficiently pulverized.

(3) The swelling or expansion on burning of the brick made of similar grains is greater when the grains are large. The expansion is practically nil for impalpable powders.

(4) The strength of the brick after drying and burning is greater as the amount of water introduced into the paste is increased.

(5) The strength of the brick after drying depends on the amount of lime added to the quartz. The strength of the brick after burning increases up to 1 per cent. of lime, remains constant between 1 and 2 per cent., and seems to decrease for more than 2 per cent.

(6) Every unit of lime added to the quartz reduces the melting point by about 20° C.

Bricks made from impalpable powder begin to harden at 800° C.

At 1,200° C. their crushing strength is about 2,700 lbs. per square inch; at 1,300° C. it is about 4,000 lbs. per square inch. Bricks made from coarser grains begin to harden only at 1,100° C. At 1,300° C. their crushing strength is only 1,000 lbs. per square inch.

The less fusible bricks are those containing the minimum of impalpable material. In a good brick the grains should not be larger than 8 mm. in diameter.

[1] La fabrication des briques de silice. Compte Rendus des séances de l'Académie des Sciences, Paris, Tome 165, No. 25, December 17th, 1917, pp. 1002-1005.

In practice silica bricks should be made from pulverized silica containing at least 96 per cent. SiO_2. Crushed Oriskany sandstone is of such a standard composition. In France silica bricks are made from a mixture of 30 per cent. impalpable powder, and 70 per cent. silica grains 1/8 mm. in diameter. The impalpable powder contains about 2 per cent. lime, the remainder being silica. The total amount of lime in the brick is thus not higher than 0.6 per cent. These bricks are burned at 1,300°C. in a tunnel kiln. They have a crushing strength of 2,800 to 3,500 lbs. per square inch. The average expansion on burning is 1.6 per cent. The absolute specific gravity is lower than 2.4, the apparent specific gravity being about 1.9. The melting point is near 1780°C. Such bricks have lasted for more than 200 runs in a Martin furnace. They are in general use in steel plants and foundries.

Physical properties of sand, grade No. 7, from Port Maitland beach, Haldimand county:

Granular metric analysis:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0	0	0	traces	0.10	10.90	83.55	97.65	99.55

Per cent. of fineness	67.58	Apparent specific gravity	1.62
Coefficient of uniformity	86.85	Weight in lbs. per cubic foot ..	101.224
Real specific gravity	2.834	Percentage of voids	42.5

Haliburton County

The Irondale, Bancroft and Ottawa railway runs through the southwest corner of Haliburton following a series of lakes and the Irondale river, a tributary of the Burnt river. In this part of the county limestone hills rise often very steeply, but in the immediate neighbourhood of the shore lines there is an alluvial plain made of sand and silt. The sand is generally ferruginous, and contains limestone and feldspar fragments. The proportion of quartz is occasionally very small. The deposits extend sometimes for miles, although they are not wider than 300 yards. In some places the pebbles become more abundant, and the material could be used for building purposes, as ballast for railroads and for road work.

Snowdon Township

In the southwestern corner of Snowdon township, there is an area covered by an apron of sand 10 to 15 feet thick and sometimes 60 feet higher than the level of the Burnt river at Kinmount. The road marking the boundary between Haliburton and Peterborough runs for about three miles through this sandy terrace, under which appear gneissoid rocks with numerous veins of pegmatite. A similar apron of sand and gravel lies along the tracks of the Grand Trunk railway, Haliburton branch, principally near the station of Gelert. North of Gelert it is seen in several road and railway cuttings, the thickness of the deposits being at some places 40 feet.

Dysart Township

In the township of Dysart a large sand and gravel pit was excavated on lot 13, concession seven, west of the railway, the material being principally used for ballast and road work. The pit is of two parts, the first being 200 by 20 by 6 yards, the second 200 by 30 by 10 yards in size. The total material removed amounts to nearly 100,000 cubic yards. The pit is not worked at present, but a reserve of 100,000 cubic yards is still available. This pit is about one and a half miles south of the town of Haliburton. On lot 14, concession seven, south of the railway, there is a smaller pit, 200 by 100 by 30 feet in size, producing sand and gravel. The deposits round the lakes at Haliburton form a sand terrace about 40 feet above the water level. The sand is ferruginous, and may be used for road and building purposes. To the north of Haliburton, small local deposits resulting from the weathering of the underlying granitic gneiss are sometimes met. Such is the case about one mile and a half north of Haliburton along the road to Moose lake. A small deposit of ferruginous sand mixed with stones was worked here and used for re-filling the adjoining road. The deposit is about 90 feet above water level at Haliburton, and the excavation 75 by 30 by 4 feet in size.

Special reference should be made here to a particular industry developed in Haliburton by Bollender Bros. Crystalline limestone is quarried about one mile east of Haliburton, on the north shore of the river, on lot 19, concession eight, of Dysart. The rock is a white dolomitic limestone, very crystalline and containing in parts numerous grains of chondrodite altering to serpentine, and small flakes of a blue greenish phlogopite. Mr. Bollender gave us the following analysis of this material:

	Per cent.
$CaCo_3$	50
$MgCo_3$	5
Impurities	5

The excavation is at present 40 by 20 by 6 yards. The work started in 1914. The rock is quarried in lumps about 6 inches in diameter and sent to the mill where it is crushed to ⅛-inch and screened to five different grades. The product is used as poultry grit, as stone dust or agricultural lime, and for mixing with cement (aggregates, plastering, floors, artificial stone, etc.), for filtering basins, and for washing compounds. The tonnage shipped in 1917 amounted to 500 tons, the average price being $4 a ton for crushed material. Some part of this production goes to the western provinces. The several grades are screened as follows:

Below 60-mesh: Fine dust used for washing compounds.

From 60-mesh to 10-mesh: Agricultural lime, mixing with cement, etc.

From 10-mesh to 8-mesh: Grit for birds and young chickens.

From 8-mesh to 5-mesh: Grit for pigeons.

From 5-mesh to ⅛ in.: Poultry grit.

Halton County

There are no deposits of importance along the shore of Lake Ontario, in this county, but in the northeastern corner of the county, round Glen Williams and Georgetown, some sand and gravel are available.

North of Glen Williams there is a sandy hill about 75 feet high and 125 feet wide where it crosses the road. This hill extends for several hundred yards on either side of the road, and contains deposits of both sand and gravel. A sand pit has been opened on the side of the hill on the property of Jos. Beaumont of Glen Williams. Only a few loads were sold in the last few years. A small gravel pit has also been opened up from which material has been taken for road work.

With regard to gravel, the most important pits lie round Georgetown. Sand beds of small thickness occur occasionally in these deposits. The gravel is rather coarse near the top, and becomes finer in the central part of the bed. It is made up of pebbles of different size and shape, mostly limestone, but there are also some pebbles of sandstone, shale, granite, and quartz. These gravels make very good material for road purposes; certain grades are self-cementing. The gravel is generally sold at 25 cents a load of 1.5 cubic yards. The various pits are indicated in the following list:

Owner	Township, Con. and Lot	Size in feet	Output per year	Remarks
Jas. Arnott, Georgetown...	Esquesing tp. Con. VII., lot 17	.....	.....	6 ft. loam to strip.
J. A. Willoughby, Georgetown...	Esquesing tp. Con. VII., lot 17($W\frac{1}{2}$)	150 by 100 by 25.	2,400 yd.	0–5 ft. to strip. Reserve, 3 ac.
James Buck, Georgetown...	Esquesing tp., Con. VII., lot 18	100 by 40 by 20.	150 yd.	Reserve, $\frac{1}{2}$ ac. Idle in 1917.
John Giffen, Georgetown...	Esquesing tp., Con. VIII.....	100 by 100 by 60.	.....	Alternate layers of gravel and sand.

The physical properties of sand from J. Beaumont's pit, Glen Williams, are shown by the granular metric analysis, as follows:

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.30	0.90	1.45	5.75	11.30	49.90	85.25	94.15	98.60

Per cent. of fineness	61.38	Apparent specific gravity	1.67
Coefficient of uniformity	73.95	Weight in lbs. per cubic foot ..	104.348
Grade	No. 6	Percentage of voids	39.6
Real specific gravity	2.766		

Granular metric analysis of gravel from J. Buck's pit, Georgetown:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	51.55[1]	65.70	75.20	91.80	96.35	99.15	99.50	99.60	99.75

Per cent. of fineness, 13.5

[1] The 51.55 per cent. remaining on the 4-mesh sieve consists of 31.40 per cent. pebbles larger than one inch, and 20.15 per cent. smaller than one inch. Some pebbles are made of cemented grains.

Hastings County

Deposits of sand and gravel are scarce in this county. There are some deposits near Belleville, but along the Bay of Quinte there is practically no gravel, nor any sand east of Belleville, before reaching Quinte point, 14 miles from the city and 8 miles west of Deseronto. The greater part of the shore of the Bay of Quinte is marked by limestone outcrops. There is a deposit of gravel west of the Prince Edward bridge, largely used for the supply of Belleville.

John Creeper's Pit.—John Creeper, Belleville, owns some sand and gravel pits situated east of the road to Madoc, in the eleventh concession of Thurlow township, just one-quarter of a mile from the limit of Belleville. These pits supply a dozen different kinds of sand and gravel. Two pits are now working, the northern one producing principally gravel, the southern pit chiefly sand. The northern pit is at present 150 by 90 by 10 feet. The deposit is principally composed of limestone pebbles, which are generally flat and angular. It looks like the upper portion of a limestone formation crumbled to pieces. Different beds

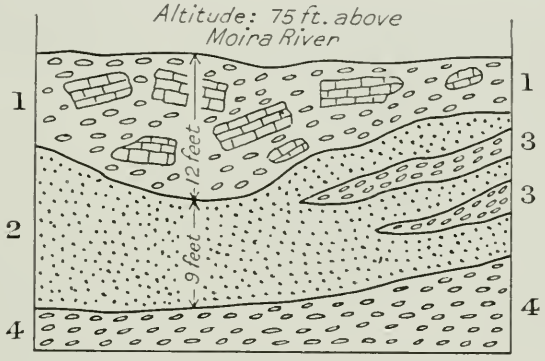

Fig. 23—Section of John Creeper's sand and gravel pit. (1) Gravel, with limestone boulders. (2) Sand. (3) Black limestone gravel layers. (4) Gravel.

are to be found in the gravel, some being more shaly and dark in colour, the others composed of limestone only. In one of the walls an anticline was very well marked. Very few granitic pebbles are to be found in the gravel, which consists mostly of material in place. The walls of the pit are vertical and hold very well. The gravel is used for road and concrete work.

The southern pit is located near the highest point of the hill, about 75 feet above the level of the Moira river, where the limestone outcrops. At present the size of the excavation is 600 by 120 by 25 feet, the longer dimension being east and west, while the depth increases to the east. The section is shown in the accompanying diagram (fig. 23). The upper part is composed of gravel with very large flat limestone boulders sometimes one yard long. Some of the pebbles are, however, of igneous rocks. The wall of the pit is about 25 feet high and stands perfectly straight. The gravel at the top is kept together by some calcareous sand and is used for making concrete. Beneath the gravel is a bed of sand eight feet thick, which is used for mortar.

Under the sand comes some black gravel which is believed to be of considerable depth. The sand is a mixture of quartz grains and calcareous material in the form of calcite and limestone grains. The calcareous nature of this sand is shown by the following chemical analysis by W. K. McNeill.

	Per cent.		Per cent.
Silica	55.46	Potash	2.04
Alumina	9.99	Soda	2.62
Ferric oxide	0.81	Carbon dioxide	11.04
Ferrous oxide	1.58	Water	0.43
Lime	14.88		
Magnesia	1.29	Total	100.14

Fig. 24.—Shallow excavation in cemented material, J. Creeper's sand and gravel pit.

Norm calculated from the preceding analysis:

Calcite	25.10	Magnetite	1.16
Orthoclase	11.68	Enstatite	3.20
Albite	22.01	Grünerite	2.24
Anorthite	4.17	Quartz	28.02
Corundum	2.04	Water	0.43
		Total	100.05

The outstanding feature of this norm is the very low content of quartz. The feldspars seem to be more abundant than one would conclude from a casual examination of the material. The large percentage of calcite explains the auto-cementing properties of this sand.

The physical properties of the sand are shown by the granular metric analysis:

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.00	0.10	0.40	4.20	13.90	60.70	86.05	93.25	98.00

Per cent. of fineness 60.38
Coefficient of uniformity 72.15
Grade ..... No. 6
Real specific gravity 2.788
Apparent specific gravity 1.70
Weight in lbs. per cubic foot ...106.223
Percentage of voids 39.0

Granular metric analysis of gravel from Creeper's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	49.80	63.85	69.50	79.10	85.55	94.45	97.55	98.55	99.30

Per cent. of fineness, 18.04.

Near Corbyville, on the eastern shore of the Moira river, on lot 6 in the fourth concession of Thurlow, a deposit of sand overlies the clay. There is about one foot of loam, then some ferruginous sand, and beneath sharp white sand. The sand is very pure, and could perhaps be used for glass-making. The property is owned by Wilson Reid.

Hungerford Township

In the township of Hungerford, deposits of sand and gravel are found in the neighbourhood of Tweed. At the northeastern end of Stoco lake, small sand deposits resulting from the weathering of granitic rocks outcropping in this area are found near the lake shore. Small sand beaches are also noticed in little bays of the lake. On lot 17, concession ten, a large sand ridge about 100 yards wide and 500 yards long extends in a southwest and northeast direction. It contains large and valuable reserves of sand for building purposes, and lies about 25 feet above the lake level. This ridge represents an old beach of Stoco lake.

On the south and western shores of Stoco lake, along the road running from Chapman to Tweed, there are several sand and gravel ridges, sometimes 100 feet above the present level of the lake. One of the ridges is located just north of Chapman, on lot 8, concession seven. A pit on this ridge supplies mostly sand, although there is also some gravel. The excavation is 60 by 20 by 10 yards. On lot 9, concession eight, a gravel pit 50 by 50 by 25 yards in size has been opened; it is located two miles south of Tweed, the gravel being mostly used for road work. Another pit on lot 10, concession nine, is one mile south of Tweed and also supplies road material. The excavation is 100 by 30 by 12 yards.

In the western part of Tweed, there is a gravel and sand ridge on the farm of W. H. Hicks. A pit 100 by 40 by 20 yards in size supplies coarse sand for building purposes and road gravel. About three miles west of Tweed there are two small gravel pits on Geo. Graham's farm, lot 3, concession eleven, township of Hungerford. Reserves are very large, but the output in 1917 was only 150 loads sold at 10 cents per load.

In the northern part of Hungerford township the country is composed of Archean rocks covered by a mantle of earth and boulders. At some places it becomes very sandy, and between Tweed and Actinolite, for instance, large areas have been covered by sand brought in by the Moira and Scootamatta rivers. Some parts of the river banks present fine sand beaches. There is in this part of Hastings a large reserve of available material, the sand being generally coarse and fit for building purposes. It contains as a rule a large amount of limestone and granitic detritus, calcite, feldspar and kaolinite being common components. This is probably the reason why crops do well on these sandy areas.

Elzevir Township

At Actinolite, in the township of Elzevir, there is a big gravel pit about 100 by 50 by 15 yards in size, the products being largely used for road work.

Between Actinolite and Queensboro, some terraces noticed along the railway are sandy, and great reserves of ferruginous sand derived from the alteration of the country rocks are available. At the lower levels more gravel is mixed with the sand, and some gravel pits have been opened in the deposits near mile 45 of the Bay of Quinte railway, close to Queensboro and Allan stations, the latter place being located in Madoc township.

Madoc Township

Similar deposits are found in the township of Madoc, at some bends of the river south of Bannockburn. The sand often contains a large amount of lime and iron, and is brown in colour. A terrace about 25 feet above the present level of the Moira river is indicated by a large deposit of sand, at least 10 feet thick, covering several acres and located on lot 24, concession five, Charles White's farm. This sand contains a large proportion of calcite grains. However, as a whole, the area around Bannockburn is rocky, and arenaceous deposits are scarce. Similar conditions prevail in Tudor and Limerick townships.

Dungannon Township

It is only near Turiff, in Dungannon township, that gravel and sandy material appear over the area made up of limestone and amphibolites. This locality is in the drainage area of the Ottawa river. The sand found here is the product of decay of the neighbouring massive rocks, and was sorted by the rivers and lakes of the country in the earlier stages of their history. It contains as a rule a large amount of lime and some silt. The stratification is often oblique. The occurrences are local, but near the Bay of Quinte railway sometimes extend over large areas. Good examples of such deposits are to be seen near Bancroft and L'Amable station. One pit is located 200 yards east of the York river at Bancroft,

on the south side of the road to Bronson, lot 63 of the gore of Faraday township. The excavation is 30 by 10 by 7 yards in size, and supplies sand and gravel. Other areas along the York river and its tributaries are covered by drift of a sandy nature, this being the case between Bronson and the bridge on the York river, along the road running east from Bancroft; and in the area northwest of Bancroft along the York river and Baptiste lake. In this northern part of Hastings, the Archean rocks appear mostly as rounded hills, the slopes near rivers and lakes being often covered by sand, gravel, silt or clay.

Huron County

The sand and gravel beach at Kincardine in Bruce county extends to the south in Huron county as far as Goderich. In the remainder of the county, sand is comparatively rare, but there are many gravel pits in the townships of Hay, Usborne and Stephen, near Crediton, Dashwood, Exeter, Hensall and Zurich. Most of these deposits are connected with the shore line of the ancient Lake Algonquin. Sometimes the bottom of the pit is of sand. The gravel is often variable in the same deposit. At the top it is generally very coarse, with some pebbles as large as 10 inches in diameter, but the regular gravel of this county is made of angular pebbles not larger than 3 inches. Finer grades such as pea gravel are found sometimes near the bottom. As to its composition, the gravel is mostly made up of limestone pebbles intermixed with sandy material. The coarse gravel is used for road making, and is sold at about 10 to 15 cents a yard, while finer cement gravel is sold at 25 to 30 cents a yard. Following is a list of the principal gravel pits in the region round Exeter and Crediton:

Owner	Township, Con. and Lot	Size in feet	Output	Remarks
Ed. Campbell. Exeter	Usborne, near N.E. corner, Con. VI			Not working.
John Cann, Exeter	Usborne, Con. V, lot 31	50 by 50 by 30		Not working, sand and gravel.
Wm. Moody, Exeter	Usborne, Con. II			Large pit.
Wm. J. Robinson, Crediton	Stephen, Con. III. lots 4, 5	200 by 60 by 16	1,000 yd.	Reserve, 1 ac.
John Rollins, Crediton	Stephen, Con. V, lot 8	125 by 75 by 6	1,000 yd.	
Peter Whitlock, Hensall	Usborne, Con. V, lot 30	3 pits about 50 by 50 by 30		
John Wood, Exeter	Usborne, Con. IV–V	600 by 300 by 12	1,500 yd.	Reserve, 8 ac., gravel and sand.

Granular metric analysis of sand in J. Cann's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained	8.85	33.10	48.10	66.45	72.85	87.80	96.50	98.45	99.35

Per cent. of fineness 32.06
Coefficient of uniformity 39.25
Grade ..... No. 2
Real specific gravity 2.718

Apparent specific gravity 1.85
Weight in lbs. per cubic foot ...115.60
Percentage of voids 31.90

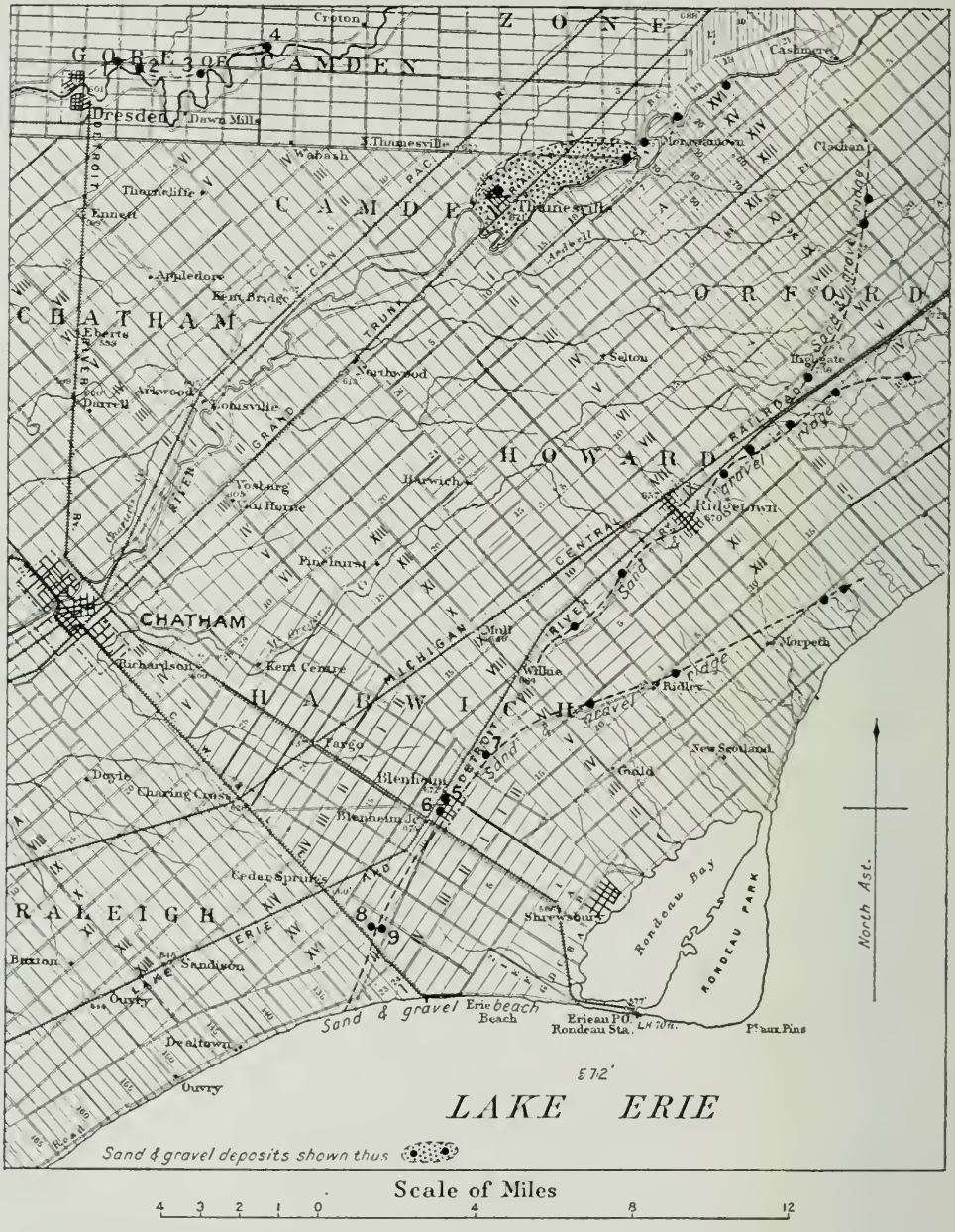

Fig. 25—Map of the eastern part of Kent county, indicating location of sand and gravel deposits. The numbers refer to the list given in the text.

Kent County[1]

In this county sand and gravel (fig. 25) are found as recent deposits along the Lake Erie shore, principally at the southwestern end of the county, in the township of Romney, and also in Harwich township, near Rondeau Park. A sandy and gravel beach 30 to 40 feet wide is met south of Cedar Springs and extends as far as Erieau and Rondeau Park. There is a clay dike north of the beach, parallel to the lake shore. At Erieau the beach is 100 yards wide and about 150 yards at the eastern end near the harbour. The sand is coarse; near the water there is a strip about 4 feet wide of limestone pebbles one and two inches in diameter. Dredging was done on this part of the shore, but has been discontinued.

Other recent deposits are found along the Thames river in Camden township and near the Sydenham river, in the Gore of Camden. The deposits along the Thames occur principally around Thamesville, and are due to floodings in this flat region. In this area, extending to the northeast as far as Moraviantown, the principal gravel pits are those owned by Arthur Tiffin and Mrs. Wm. Watts. The pit of Mrs. W. M. Sherman, in Thamesville, is a sand pit. The sand is pure and coarse. The gravels of this area are generally fine and made of limestone pebbles. The sand is sold at about 25 cents a yard, the gravel at 15 cents. At the top of these recent deposits of sand there is sometimes a small layer of moulding sand. Such is the case at Arthur Tiffin's pit, where at places this layer is two feet thick.

The recent deposits near the Sydenham river are located around Dresden. They are generally of coarse sand containing some pebbles, and are used for cement work. There is here also some moulding sand at the top of the deposits.

Herewith are particulars of the pits about Thamesville and Dresden:

No.	Owner	Township and Con. and Lot	Size in feet	Output	Remarks
1 } 2 }	Rice, Geo. A. and Sons, Dresden	Gore of Camden, Con. III and IV, lot 5	60 by 60 by 8	140 yd.	3 ft. earth at the top, some moulding sand.
3	——Sharp, Dresden	Gore of Camden, Con. VI, lots 4 and 5	100 by 100 by 10	.....	South shore of river.
4	——Richards, Dresden	Gore of Camden	.....	.....	Not working.
	Arthur Tiffin, Thamesville	Camden, Con. X, lot 6	300 by 100 by 7	.....	2 ft. of soil on top.
	Mrs. Wm. Sherman, Thamesville	Camden	200 by 100 by 10	.....	2½ ft. to strip. Reserve 2 ac.
	Wm. Watts, Thamesville	Camden	300 by 75 by 8	.....	Large reserve.

Besides the recent deposits there is an extensive sand and gravel ridge running from Lake Erie, about south of Cedar Springs, in a northeasterly direction, and passing through Blenheim, Wilkie, Ridgetown, Highgate, and Clachan, thus extending over the townships of Harwich, Howard and Orford. East of Blenheim the ridge subdivides into two branches, the southern one passing through Ridley, Morpeth and Palmyra. The ridge is of variable width and depth; it has its largest

[1] For further details respecting road material in the county of Kent, see L. Reinecke's Report, op. cit., pp. 115-137.

width, 600 ft., at the southwestern end near the lake shore; the depth varies between 5 ft. and 60 ft. The material comprises different grades of sand and coarse gravel. In the following table are given some details of the principal pits visited.

No.	Owner	Township, Con. and Lot	Size in ft.	Output	Remarks
5	—— Blenheim	Harwich, Con. I, lot 10.	150 by 75 by 7	.....	Sand pit.
6	Ross. Blenheim	Harwich, Con. I, lot 11.	100 by 60 by 6	.....	Gravel of fine grade.
7	Young, Blenheim.....	Harwich, Con. II, lot 10.	.....	.....	Worked out.
8	Wallaceburg, Chatham and Lake Erie Ry. Co.....	Raleigh, Con. II, lot 24	500 by 150 by 30	.....	Coarse and pea limestone gravel, sandstone and a little shale.
9	Townships of Raleigh and Harwich.....	Raleigh, Con. II, lot 24	75 by 75 by 30	.....	Fine gravel, some iron oxide.

Granular metric analysis of sand, Geo. Rice and Sons, Dresden:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	1.75	12.00	21.00	38.80	45.75	63.20	88.50	95.85	98.10

Per cent. of fineness 48.34
Coefficient of uniformity 42.75
Grade ..... No. 6
Real specific gravity 2.578

Apparent specific gravity 1.65
Weight in lbs. per cubic foot ...103.10
Percentage of voids: Calculated.. 36.0
Measured . 34.5

Granular metric analysis of sand from Arthur Tiffin's pit, Thamesville:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	2.40	4.45	5.85	9.70	12.50	34.10	82.65	91.45	95.95

Per cent. of fineness 62.33
Coefficient of uniformity 70.15
Grade ..... No. 6
Real specific gravity 2.748

Apparent specific gravity 1.66
Weight in lbs. per cubic foot... 103.72
Percentage of voids 39.60

Lambton County

A line of deposits (fig. 26) passing through Copleston, north of Petrolia, Wyoming, north of Watford, and bending then slowly to the north, while passing through the counties of Middlesex and Huron, runs about parallel with the present shore of Lake Huron at an average distance of ten miles. These deposits are probably connected with an old shore line of Lake Algonquin. Numerous pits have

been opened at the several places mentioned, as the deposit extends over a large area and contains great reserves of sand and gravel. The ridge is sometimes wider than 1,000 feet, and in this county alone from the Copleston area east, it runs for more than twenty miles. It supplies good building sand, cement gravel and road gravel. Gravel is the predominant material, and this consists principally of limestone; around Petrolia and Copleston there is very little slate among the pebbles, but in some places, as at Watford, the quantity of limestone becomes smaller, and most of the pebbles are shale in a state of alteration to clay and iron oxide. When used

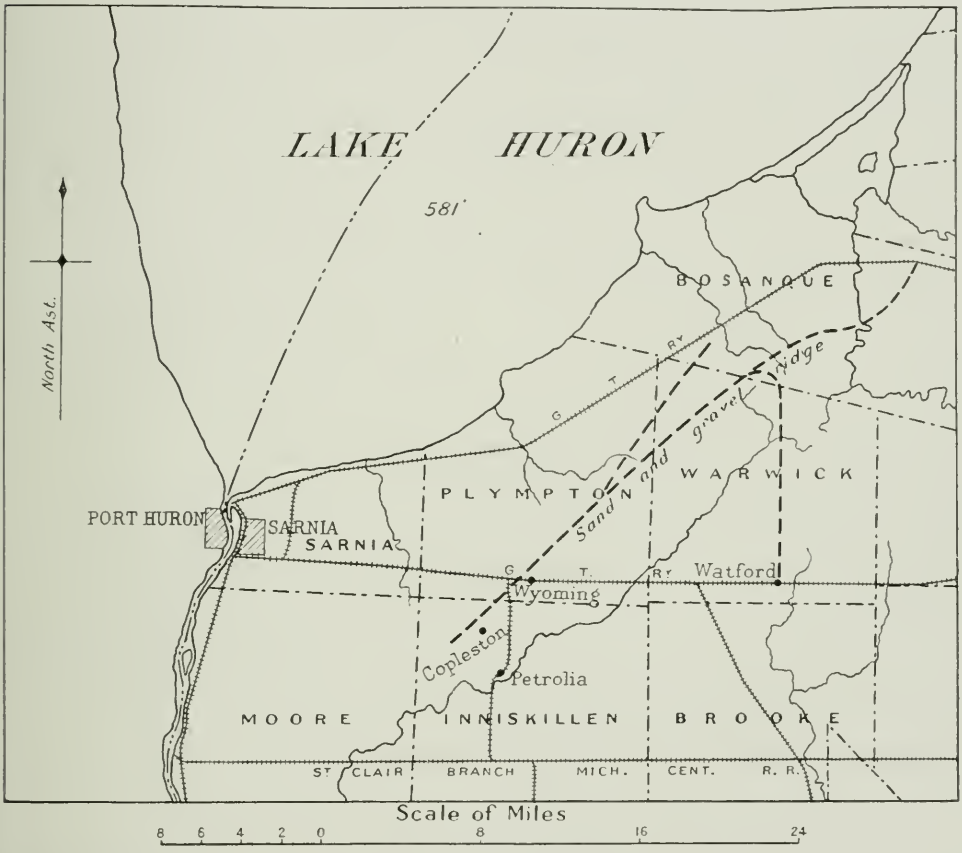

Fig. 26—Northern part of Lambton county, showing the location of the sand and gravel ridge passing near Copleston, Wyoming and Watford.

on roads such gravel produces a large amount of fine dust. The poor quality of such road gravel explains why it is sold at 16 cents a yard in the pits near Watford, while at Copleston the average price is 50 cents a yard. The working of the pits is very often done in a wasteful way, 3 or 4 feet generally remaining unworked at the bottom of the pit. The teamsters loading the gravel in a pit prefer to take the upper layers, as they are much more easily shovelled into their wagons; or they take only the very best material, that of inferior quality being disregarded and covered by loam and earth.

The following list gives some details about the deposits connected with the shore line of the ancient lake Algonquin:—

Owner	Township, Con. and Lot	Size in ft.	Output	Remarks
John W. Cann, Copleston	Enniskillen, Con. XIII, lot 7.	150 by 150 by 7	200yd.	Cement gravel, ferruginous at the bottom. Reserve 2 acres.
Enniskillen tp., Petrolia.	Enniskillen, Con. XIII.	300 by 150 by 10	1,000 yd.	Sand and gravel. Reserve 2 acres.
Estate, J. Kerr, Petrolia.	Enniskillen, Con. XIII, lot 9.	300 by 200 by 10	.....	Sand and cement gravel. Reserve 1.5 acre.
John Kerr, Petrolia	Enniskillen, Con. XIII, lot 13.	150 by 150 by 15	2,000 yd.	Sand and gravel. Reserve 0.5 acre.
Robert Kettle, Petrolia..	Enniskillen, Con. XIII, lots 7 & 9	Two pits, 60 by 60 by 10, 300 by 150 by 8.	500 yd.	Sand and gravel 23 ft. deep. Reserve 20 ac.
Wm. Kettle, Petrolia....	Enniskillen, Con. XIII.	325 by 100 by 12	500yd.	Sand and gravel. Reserve 10 acres.
Jno. McPhedran, Petrolia	Enniskillen, Con. XIII.	300 by 300 by 10	.....	Sand and gravel. Reserve small.
Robt. Whiting, Copleston.	Enniskillen, Con. XIII, lot 13.	400 by 150 by 8	1,000 yd.	Cement gravel. Reserve 1.5 acre.
Jno. Wooley, Petrolia....	Enniskillen, Con. XIII, lot 7.	500 by 125 by 6	.....	Gravel of variable grade, 12 ft. deep. Reserve 1.5 acre.
Richard Bryson, Wyoming	Plympton, Con. V, lot 18.	100 by 100 by 12	200yd.	Gravel and sand.
Thos. Conboy, Wyoming..	Plympton, Con. V, lot 17.	10 deep.....	.....	Gravel. Reserve 1.5 ac.
Corporation of Wyoming.	Plympton, Con. I, lot 16.	200 by 100 by 6	.....	Gravel.
G. T. R., Wyoming.....	Plympton, Con. I, lot 16.	400 by 200 by 10	.....	Gravel.
Lucas, Wyoming.....	Plympton, Con. V, lot 18.	200 by 100 by 10	750yd.	Cement and road gravel, and sand.
Isaac Mariett & Son, Wyoming.	Plympton, Con. V, lot 18.	400 by 125 by 7	.....	Not worked.
Stonehouse, Wyoming....	Plympton, Con. I, lot 15.	1 acre by 15 ft..	750yd.	Road gravel.
Robt. Fleming, Watford..	Warwick, Con. IV, lot 17.	600 by 150 by 4	250yd.	Cement gravel. Reserve 1 acre.
Robt. Lucas, Watford....	Brooke, Con. XII, lot 12.	300 by 150 by 12	300yd	Road gravel. Reserve 3 acres.

Granular metric analysis of sand from R. Kettle's pit, Copleston:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	1.30	2.80	6.15	8.95	43.80	86.10	93.85	98.40

Per cent. of fineness	62.07	Apparent specific gravity	1.62
Coefficient of uniformity	77.15	Weight in lbs. per cubic foot...	101.22
Grade	No. 6	Percentage of voids	40.8
Real specific gravity	2.738		

Granular metric analysis of gravel from R. Kettle's pit, Copleston:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	57.15	62.35	63.75	66.10	68.15	89.15	97.95	98.70	99.30

Per cent. of fineness, 21.93.

Other deposits of sand and gravel occur in the county of Lambton. Ten miles north of Wyoming, there is a gravel beach along the shore of Lake Huron. In the township of Euphemia, there are some pits round Aberfeldy and others near Cairo. The walls of these pits are made of alternate layers of gravel and sand. This material is sold at 75 cents a yard in the pit. There are only two pits working at present:—

Owner	Township, Con. and Lot	Size in feet	Output	Remarks
Samuel Turtle, Aberfeldy.....	Euphemia, Con. IV, lot 26.	200 by 100 by 12	600yd.	The gravel does not contain pebbles larger than 2 in. Reserve: 60 acs.
John L. Munroe, Cairo	Euphemia.	250 by 75 by 8	.....	Fine gravel and sand. Reserve: 1.5 acs.

Lanark County

There is some gravel near Smiths Falls which was extensively used by the railway companies for ballast. Near Perth, there is some sand and gravel.

The deposit used by the Canadian Northern Railway company, two miles north of Smiths Falls, in the township of Montague, extends over about 20 acres, with an average depth of 10 feet. It was worked by steam shovel, and about half of the gravel has been taken out.

The gravel pit owned by George Kerfoot, Smiths Falls, is in the township of Montague, lot 26, concession eight. It is about 3.5 miles north from Smiths Falls, near the tracks of the Canadian Pacific railway. The average depth of the pit is 10 feet, below which clay is found. The material is about two parts of gravel to one of sand. Two hundred cubic yards were taken out in 1916, and sold for delivery in town at $1.75 per cubic yard. There is an estimated reserve of three acres.

Leeds County

Deposits of sand and gravel in this county are scarce. Some sand and gravel used by the corporation of Brockville is obtained from the St. Lawrence river, about ten miles west of the city. It is supplied by J. H. Simpson, Lyn.

As to pit material, one deposit is owned by Geo. E. Sherwood, Prescott Road, Brockville, situated in Elizabethtown township, lot 3, concession one. The present excavation is 200 by 100 by 10 feet. The material consists principally of gravel, with some sand. The pebbles are angular, and are generally dolomitic limestones or metamorphosed rocks; this gravel is used for concrete work. The

sand contains a little loam, but by sifting a good sharp building sand is obtained. The output of 1916 was 500 cubic yards, sold at $1.25 a cubic yard for delivery in Brockville. The available reserve extends over six acres.

Jos. H. Morrison, Brockville, owns a deposit of sand and gravel near Lyn, in Elizabethtown township. The reserve extends over three acres, and the present pit is 25 feet deep. The output of 1916 was about 800 cubic yards, sold at $1.75 for delivery in Brockville.

Some moulding sand occurs in a sand pit two and a half miles west of Brockville. It is owned by T. H. Bresee and is situated on lot 20, concession one, Elizabethtown. The moulding sand extends here over a large area, covered by bushes. Trenches were dug at 4 feet depth and an average thickness of 2 feet of moulding sand was discovered. Three hundred tons of this sand are used in one year by foundries in Brockville and Smiths Falls, replacing an equal quantity of Albany moulding sand. Below is given a chemical analysis of this material by W. K. McNeill, Provincial Assayer.

Moulding sand, Bresee farm, near Brockville:—

	Per cent.		Per cent.
Silica	74.80	Soda	3.43
Alumina	11.25	Carbon dioxide	0.60
Ferric oxide	2.11	Water	0.62
Lime	2.92	Ferrous oxide	1.89
Magnesia	0.41		
Potash	2.20	Total	100.23

The alumina and alkalies are probably the result of the disintegration of feldspars, and the iron oxides are due to the alteration of ferro-magnesian minerals.

Norm calculated from the preceding analysis:—

Calcite	1.40	
Orthoclase	2.79	50.78 feldspars
Albite	28.82	
Anorthite	9.17	
Magnetite	3.02	
Wollastonite	0.58	
Enstatite	1.00	
Grünerite	1.72	
Quartz	41.05	
Water	0.62	
Total	100.17	

The large proportion of feldspars and quartz indicates that this sand is one of the final stages of the weathering of a granitic rock. The bonding power is due to a certain amount of kaolinite and ferric hydroxide not indicated in the norm.

At the opposite or southwestern end of the county, there is a deposit of sand on a granite hill, two miles north of Gananoque. A pit owned by Fred C. Gray, of Gananoque, is located on this hill, in lot 11, concession one of the township of Leeds. The size of the pit is about 120 by 120 by 15 ft. Most of this material is fine sand derived from granitic minerals, and some pebbles. There are two feet of moulding sand near the top. The total average output is 3,000 yards a year. It is sold at 25 cents a cubic yard at the pit and $1.25 for delivery in Gananoque. The reserve is 15 acres. There is a small gravel pit, about 200 yards southwest from the sandpit.

In the township of South Elmsley, in the northern corner of the county, there is some good gravel. One pit located in lot 10, concession three, is operated by James Shanks, Smiths Falls. The present excavation is 100 by 100 by 8 feet, the bottom being limestone. About 70 per cent. of the material is gravel, the remainder being sand. The gravel is coarse and is used for road-making. The pebbles vary between four inches and one quarter of an inch in diameter. They consist mostly of limestone, with some granitic and metamorphic rocks.

Granular metric analysis of sand from James Shanks' pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained ..	20.00	22.90	25.20	37.50	52.55	93.45	97.80	98.30	98.95

Per cent. of fineness	39.26	Apparent specific gravity	1.77
Coefficient of uniformity	55.95	Weight in lbs. per cubic foot ..	110.60
Grade	No. 5	Percentage of voids	35.10
Real specific gravity	2.729		

Granular metric analysis of coarse sand from Fred C. Gray's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.40	1.20	1.85	5.55	18.45	75.05	93.50	97.30	98.90

Per cent. of fineness	56.42	Apparent specific gravity	1.67
Coefficient of uniformity	75.05	Weight in lbs. per cubic foot ..	104.35
Grade	No. 6	Percentage of voids	40.50
Real specific gravity	2.807		

Granular metric analysis of fine sand from Fred C. Gray's pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.00	0.00	0.00	traces	0.10	24.60	76.20	90.60	98.05

Per cent. of fineness	67.83	Apparent specific gravity	1.64
Coefficient of uniformity	76.10	Weight in lbs. per cubic foot ..	102.47
Grade	No. 6	Percentage of voids	41.80
Real specific gravity	2.822		

Lennox and Addington County

The area round Napanee in the townships of Richmond and Fredericksburg is made of slaty limestones of the Trenton formation. About ten miles south of Napanee this slaty limestone occurs as an escarpment along the shore of Lake Ontario. The weathering and disintegration of the rock produces a limestone gravel, made of discoid pebbles of greatly varying sizes, from a few millimetres up to one foot in diameter. The deposit of gravel is only two or three feet thick, and occurs very often on a width of ten yards along the escarpment. Some large boulders of gneiss and granite occur along the lake shore, and pebbles of this material are found in small quantity in the gravel. The gravel is used for road work in the vicinity of the lake shore.

On the Napanee River

Northeast of Napanee, the Napanee river runs through a valley containing numerous alluvial deposits of sand and gravel. This river comes from Frontenac county, enters the township of Camden, and passes through Colebrook, Yarker, Camden East, Newburgh, Strathcona and Napanee, this last town being in the township of Richmond. On both sides of the river slowly grading slopes are covered by alluvial deposits until 100 feet above the river level. At this line begins a nearly vertical escarpment of limestone. The sand is coarse and makes good material for building purposes. It contains pebbles of limestone, and of granitic or gneissoid rocks coming from the eastern pre-Cambrian area. Large boulders are also found in these deposits.

Good deposits of this kind occur east of the bridge on the Napanee river, about half-way between Napanee and Newburgh. A pit of 60 by 30 by 12 feet is opened south of the Napanee-Newburgh road in the township of Camden, on lot 5, concession one. It belongs to David Mowears, the deposit extending over three acres of his property. The sand layers show oblique stratification. The material is used for building purposes and for road work and is sold at 25 cents a load.

The largest sandpit south of the river was the one operated by R. C. Katon, township of Camden, lot 6, concession one, but it is not worked at present. Another pit south of the river belongs to M. Emptey, township of Camden, lots 8 and 9, concession one.

On the northern shore of the Napanee river, east of Strathcona, and about one mile west of Newburgh station, there is a large alluvial deposit of sand and gravel with some silt. It has been used for a length of 500 yards by the Canadian Northern railway for ballast. The width of the pit is from 60 to 75 yards, and the average depth 10 yards. The material removed amounts thus to nearly 500 by 70 by 10 = 350,000 cubic yards. Large reserves are still available. The material is more silty and not so suitable for building purposes as the one found on the south shore.

Another large pit is located 200 yards east of the Newburgh graveyard, between the Napanee-Yarker road and the river. Sand and gravel are found in this pit, the material being of good quality. It is worked on a length of 150 yards in a direction parallel to the river, an average width of 25 yards, and an average depth of six yards. The upper part is as a rule of sharp sand, with very few pebbles: the lower part is gravel, the two parts being sometimes separated by a thin layer of clay. The whole deposit shows oblique stratification.

In Camden East, Sidney Williams opened a sand pit on the north shore of the river. The material is used for building purposes. This pit is 125 yards long and 8 yards deep, and is located between the C.N.R. tracks and the graveyard.

The area along the C.N.R. between Camden East and Tamworth is mostly covered with limestone boulders and some granitic material. In the cuttings between Enterprise and Tamworth, several local deposits of gravel produced by the disintegration of the underlying rocks are noticeable.

Sheffield Township

In the township of Sheffield, some deposits occur in the area around Tamworth. North of the station of Erinsville, about two miles west of Tamworth, a gravel and sand ridge occurs on the west shore of Beaver lake. One pit of 150 by 75 by 30 feet has been opened by P. McCann, in the township of Sheffield, on lot 8, concession three. Most of this material is the product of decomposition of granite, metamorphic schists, and limestone. Large pebbles and boulders of these rocks are found in the deposit. The sand is coarse and suitable for building purposes, but the market is small and very little is taken out in a year: the selling price is 15 cents per load. Another gravel pit, belonging to Mr. Anderson, Erinsville, is located on the north shore of the C.N.R. Little work has been done in it lately.

About one mile and a quarter west of Erinsville, near the boundary between the counties of Lennox and Addington and Hastings, there is a very large gravel pit belonging to the C.N.R. and used for ballast supply. The pit is not worked at present, but the excavation is 300 by 100 by 20 yards in size, representing a removal of 600,000 cubic yards. The reserve contains at least 1,200,000 cubic yards. The pit is located on lot 5, concession two, Sheffield, north of the C.N.R. tracks. The gravel exhibits oblique stratification. On top of the ridge the material is a little silty.

The area between Beaver lake and White lake is near the contact of granitic and sedimentary rocks. It is covered by numerous drumloid hills made of sand and gravel. Similar hills occur east of Beaver lake, and in one of them is situated a pit owned by H. Cunningham, Tamworth. It produces sand and gravel, the former coarse, the latter made up of pebbles of various rocks, rather angular in shape. The excavation is small: 30 by 15 by 4 feet, but there are large reserves available. The material is used for road work and building purposes, road gravel being sold at 10 cents per load.

Similar deposits occur in the township of Kaladar, near Addington and Kaladar.

Lincoln County

In this county the shore line of the glacial lake Iroquois extends from Queenston, at the east, to Grimsby, at the west, passing through St. David, Homer, St. Catharines, Jordan, and Beamsville. It lies between the Niagara escarpment and the Lake Ontario shore, but is not marked by a continuous line of sand and gravel deposits. Only some small bars occur here and there along this line, as at Homer and St. Catharines, but they are without economic importance.

White sandstone, which may be suitable for making glass or ferro-silicon, has been found under the red Medina sandstone on the Niagara escarpment. Outcrops of this white sandstone may be seen along the Michigan Central railway northeast of St. David. It consists of layers about 10 inches thick, alternating with small bands of shale. Above the railway the white rock outcrops for about 15 feet underlying, in succession upwards, 8 feet of red sandstone, 3 feet of bluish calcareous shale, and the dolomitic limestone of the top. Assuming that the white sandstone runs one mile in length along the railway with a probable thickness of

12 feet, each yard under the plateau would represent a reserve of 2,000 by 4 = 8,000 cubic yards. Below is given a chemical analysis of this white sandstone by W. K. McNeill:—

White sandstone, Queenston Quarry Co., St. David:—

	Per cent.
Silica	93.36
Alumina	2.54
Ferric oxide	0.75
Ferrous oxide	1.13
Lime	0.90
Alkalies	0.83
Magnesia	0.37
Carbon dioxide	0.22
Water	0.23
Total	100.33

Norm calculated from the preceding analysis:—

Calcite		0.50
Orthoclase	2.78	8.98 feldspars
Albite	3.14	
Anorthite	3.06	
Corundum		0.31
Enstatite		0.90
Grünerite		1.45
Magnetite		1.16
Quartz		86.88
Water		0.23
Total		100.41

The proportion of quartz in this rock is very high, contrasting with the small amount of feldspars and of iron-bearing minerals.

Middlesex County

Deposits of gravel are very abundant in this county; sand also occurs, but in smaller amount. The principal locations are: London, Thorndale, Dorchester, Lucan, and Parkhill. In the last locality the deposits belong to the old shore line of lake Algonquin; in the other localities they are connected with the history of the Thames river and its tributaries.

In the city of London large quantities of gravel are taken from the north branch of the river; most of this gravel is washed from the gravel banks west of Adelaide street. On the south branch there are only small deposits, and on the main stream there is nothing of interest above the cove, west of the G.T.R. bridge. The principal deposits in the river and pits of sand and gravel are marked on a map of London (fig. 27). The pits are numerous; practically the whole north-western part of the city is on gravel, while in the eastern and northeastern parts the sub-soil is all sand. Sewer excavations at 20 feet in depth in Egerton street have shown the sand at the bottom. The upper parts are generally of good sharp building sand, while the deeper parts become finer and approach quicksand. The gravels vary in size of pebbles from one pit to another, affording supplies of road and cement gravel. The pebbles are mostly of limestone fragments intermixed with some igneous and metamorphic rocks. This material is delivered in various wards at prices varying from 50 cents to $1.25 a cubic yard. The city of London used in 1916 about 50,000 cubic yards of gravel. These figures were obtained from H. A. Brazier, city engineer.

Near Thorndale the gravel pits supply gravel of similar kind. About 80 per cent. is limestone, the pebbles being sometimes as large as four inches in diameter. This material is used for road building and is sold at 20 cents per cubic yard. Southwest of Thorndale there is an area of several square miles covered by such gravel.

At Dorchester, in the southeastern part of the county, the gravel is mixed with coarse and sharp sand, one-half of the material being gravel, the other half sand. Fifty per cent. of the pebbles are limestone. The deposit extends on both sides of the Thames river. There are several deposits of this kind between Dorchester and Sandpit, near London.

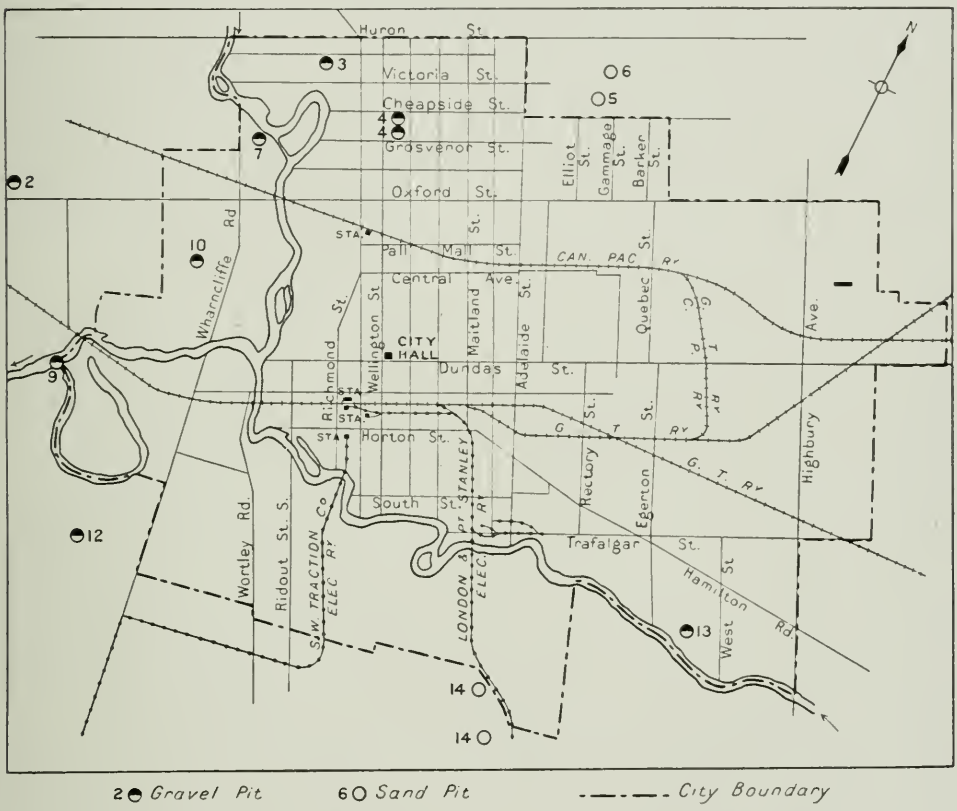

Fig. 27—City of London, Ont., with location of sand and gravel deposits. Scale: one mile to the inch. The numbers refer to the list given in the text.

In the township of Biddulph, in the north of the county, there are some gravel pits round Lucan and Clandeboye. The material is made of pebbles generally under 5 inches and coarser near the top.

The fine grade of the gravel found near the bottom of the pits is sometimes auto-cementing, and has some value as a cement gravel.

The deposits in the neighbourhood of Parkhill are numerous. They are located in the townships of West Williams, East Williams, and McGillivray. As to the quality, the ridge contains road and concrete gravel, the first being sold at 10 cents, the second at 25 cents a yard at the pit. The average depth of the deposits approaches 10 feet.

The following list gives some details about the principal pits in Middlesex county:—

No.	Owner	Location	Size in feet	Remarks
1	——, London....	North Branch of the Thames, between Oxford and Adelaide Sts., London.....	.....	River gravel.
2	——, London....	Near Jewish Cemetery, north side of Oxford St., London...	150 by 75 by 10	Gravel pit. Double of actual area in reserve.
3	——, London....	Angle of Regent and Talbot Sts., London	150 by 60 by 4	Road gravel pit.
4	——, London....	Block between Cheapside, Wellington, Grosvenor, Waterloo Sts., London	20 deep	Gravel pit; quite exhausted
5	Builders' Supply Co., London	South of Eastern end of Victoria St., London.....	300 by 150 by 15	Sand pit.
6	Boss, Lower London	North of eastern end Victoria St., London	100 by 100 by 15	Sand pit.
7	——, London....	Near river; angle of Beaufort St. and Wharncliffe Road,	300 by 150 by 12	Two gravel pits. Similar
8	M. Stincombe, London	London	150 by 150 by 12	area in reserve.
		.....	75 by 75 by 10	Gravel hill.
9	——, London....	Island at mouth of cove, Thames main branch, London.....	250 by 50	Gravel.
10	——, London....	Paul St., London	.....	Gravel.
11	——, London....	Outside and west of city; along Pipe Line Road.....	.....	Gravel pits.
12	——, London....	West of Alexandra Ave. London	.....	Gravel pit.
13	——, London....	Southeastern part Egerton St., London	.....	Gravel pits.
14	——, London....	Near Base Line, Westminster tp., W. of London & Port Stanley Ry.	.....	Two sand pits.
15	Mrs. Henderson, Thorndale	Nissouri, W. tp., Con. I, lot 15.	500 by 150 by 10	Road gravel. Res., 4 acres.
16	Walter Bryan, Thorndale	Nissouri, W. tp., Con. I, lot 16.	100 by 100 by 15	Road gravel. Res., 2 acres.
17	Henry Baskerville, Thorndale	Nissouri, W. tp., Con. III, lot 5.	300 by 300 by 10	Road gravel. Res., 2 acres.
18	Raywood Bott, Thorndale	Nissouri, W. tp., Con. V, lot 2..	100 by 100 by 15	Two gravel pits. Ridge, 500
19	Wm. Smith, Thorndale	Nissouri, W. tp., Con. IV, lot 3.	100 by 100 by 15 150 by 150 by 12	yd. long and 100 yd. wide. Road and cement gravel. Reserve, 25 acres.
20	Geo. Showler, Dorchester	Dorchester, N. tp., Con. III, lot 4	300 by 150 by 6	Gravel and sand.
21	Michael Armitage, Lucan	Biddulph tp., Con. IV	Small	Gravel pit.
22	Geo. Hodgins, Lucan	Biddulph tp., Con. IV.....	Small	Gravel pit.
23	John S. Park, Lucan	Biddulph tp., Con. II, lot 30....	300 by 200 by 20	Road and cement gravel. Reserve, 4 acres.
24	T. Appleton, Parkhill.....	McGillivray tp., Con. XIX, lot 10	100 by 100 by 12	Road and cement gravel.
25	Lewis H. Durr, Parkhill.....	McGillivray tp., Con. XVIII....	300 by 200 by 6	Cement gravel. Reserve, 2.5 acres.
26	John Grieves, Parkhill.....	East Williams tp., Con. VIII...	300 by 300 by 4	Cement gravel.
27	—— Hartle, Parkhill.....	McGillivray tp., Con. XVIII..	200 by 50 by 10	Road and cement gravel.
28	Wm. Smithers, Parkhill.....	McGillivray tp., Con. XIX, lot 10	250 by 40 by 12	Gravel and sand. Reserve, 3 acres.
29	Wesley Harris, Kerrwood	Adelaide tp., Con. IV, lot 1	200 by 150 by 20	Sand and gravel. Exhausted.
30	Waltham, Kerwood.	Adelaide tp., Con. IV, lot 2.....	300 by 300 by 20	Sand and gravel. Exhausted.
31	Rivers, Kerwood..	Adelaide tp., Con. III, lot. 1....	200 by 75 by 15	Road and cement gravel. Reserve, 1 acre. Output, 1,000 cu. yd.
32	Chambers, Kerrwood	Adelaide tp., Con. III, lot. 2....	225 by 175 by 30	Road gravel. Res., 10 acres.

Granular metric analysis of sand, Builders' Supply Co. pit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.50	4.55	10.50	29.15	45.55	92.55	99.90	100.00	100.00

Percent. of fineness	46.37	Apparent specific gravity	1.65
Coefficient of uniformity	63.40	Weight in lbs. per cubic foot	103.10
Grade	No. 5	Percentage of voids	39.3
Real specific gravity	2.718		

Granular metric analysis of gravel from fourth pit in list:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	96.25[1]	99.45	99.85	100.00	100.00	100.00	100.00	100.00	100.00

Per cent. of fineness, 0.49.

Muskoka District

In this district, where the rock formations are principally granitic, the gravels and sands are due to the weathering and to the glacial erosion of the rocks. In the southern part of the district along the Grand Trunk railway tracks, a fine, yellow and loamy sand appears as the result of the weathering. It is associated with gravel, of which large quantities are available round Bracebridge and Gravenhurst. Near the last-mentioned place, in the township of Muskoka, the deposits have been partially worked by the railway company. At Bracebridge, in Draper township, the two principal pits are located in the thirteenth concession, southeast of the town.

Ollivero's pit, on lot 4, is an excavation of 150 by 150 by 20 feet, with lenticular formations of sand and gravel. The material is sold at 10 to 20 cents a cubic yard.

John Watson's pit, on lot 5, is about 100 by 100 by 15 feet in size. It contains sand, cement, and road gravel, and also some big boulders near the top. The output in 1916 was about 150 cubic yards, and the selling price was about 10 cents a yard.

Granular metric analysis of sand from John Watson's pit, Bracebridge:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.40	3.50	9.50	29.45	46.45	75.90	90.55	95.05	98.40

Per cent. of fineness	50.09	Apparent specific gravity	1.65
Coefficient of uniformity	46.45	Weight in lbs. per cubic foot	103.10
Grade	No. 5	Percentage of voids: Calculated	39.80
Real specific gravity	2.744	Measured.	35.70

[1] Of the 96.25 per cent. remaining on the 4-mesh sieve, 66.10 were pebbles larger than one inch.

More to the north, round Huntsville, in Chaffey township, several deposits of sand and gravel occur near the lake and river shores. At the locks of the Muskoka river, lot 13, concession twelve of Brunel township, there are large deposits extending about one mile south of the locks, on both sides of the river. The ridge is highest on the west side near the locks, where the deposit is 50 yards thick and 5,000 yards wide. The material is made up of sand of various grades and is used for building purposes and for road work.

At Fairyport, on the south shore of Fairy lake, lot 19, concession thirteen, there is a small sand beach and some sand banks about 30 feet above the lake level. Similar deposits occur in the neighbouring bay at Hollinshead's.

On the north shore of Peninsula lake some sand occurs in concession one of Chaffey township, between Deerhurst and Grassmere.

On the southwestern shore of Mary lake there are sand and gravel deposits around Port Sydney, in the township of Stephenson.

The northeastern shore of Lake Vernon is marked by some deposits of sand, gravel and clay, principally south of the mouth of the East river and also opposite May island.

All these arenaceous deposits in the Lake of Bays district are remnants of a former stage of the physical history of this area, when it was occupied by one large lake, the actual hills being small scattered islands.

Norfolk County

There is some sand and gravel available on the Lake Erie beach at Port Dover, west of the lighthouse overlying a substratum of clay, which rises in the form of cliffs along the beach. Near the shore are deposits of pea gravel, of blue and white limestone, also igneous and metamorphic rocks. The pebbles are less than half an inch in diameter, and are angular in shape. Beyond the gravel comes a zone of white or yellow, and farther up, near the clay cliffs, a red garnetiferous sand. Sometimes heavy winters with much wind and ice bring large deposits of gravel to the beach, this material being carted away in the spring. On this account there is often no gravel left on the beach in the summer. The gravel is sold at 15 cents a yard on the spot and $1.65 for delivery in town. There are large reserves of building sand to be found on the beach. Its only defect is a small proportion of vegetable matter.

In the corporation of Simcoe a deposit of sand about 10 acres in size has been worked by Arthur Coats. The size of the present excavation is 100 by 150 feet, with a depth varying from 6 to 20 feet. The upper part consists of two feet of soil, below this come 6 feet of good sharp sand, and then about 12 feet fine white sand. The sharp sand is sold at about $1.00 a cubic yard, for delivery in town.

There are valuable reserves of gravel between Simcoe and Watford, in the township of Townsend, but they are not being worked at present. To the south of Simcoe, there is a gravel pit in Charlotteville township, on lot 24, concession nine, belonging to Mr. Weston and Mrs. Wright. The excavation is 100 ft. by 500 feet by 8 feet. The material, coarse at the top, becomes finer near the bottom, and is made up principally of angular limestone pebbles. There is an approximate reserve of one acre of similar material. A bucket elevator, screens and bins represent the equipment in this pit.

To the southeast of Simcoe, in the township of Woodhouse, Mr. Decew owns a sand and gravel pit on lot 1, concession five, the present excavation being 120 by 120 by 10 feet, with an equal area in reserve. The output in 1916 was 2,000 yards, which sold at 50 cents per yard. A certain proportion of the sandy soil at the top of this deposit could be used as a pipe moulding sand.

Granular metric analysis of white beach sand, Port Dover:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0	0	tr	tr	tr	53.80	97.10	99.25	99.45

Per cent. of fineness	61.16	Apparent specific gravity	1.70
Coefficient of uniformity	97.10	Weight in lbs. per cubic foot	106.22
Grade	No. 6	Percentage of voids	43.60
Real specific gravity	3.017		

Granular metric analysis of red beach sand, Port Dover:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0	0	0	tr	tr	8.60	83.60	98.70	100.00

Per cent. of fineness	67.68	Apparent specific gravity	2.29
Coefficient of uniformity	90.10	Weight in lbs. per cubic foot	143.09
Grade	No. 7	Percentage of voids	44.40
Real specific gravity	4.123		

Northumberland County

The shore line of ancient Lake Iroquois crosses this county in a direction parallel to the shore line of Lake Ontario. Gravel and sand deposits are closely connected with the old shore line near Baltimore, Colborne, Brighton and Trenton. In the southeastern corner of the county, near Trenton, there are several beach levels with their related gravel and sand bars.

The gravel pits of the Baltimore and Cobourg Gravel Road Co. of Baltimore are situated one mile south of Baltimore, in the township of Hamilton, on lot 7, concession two. The principal pit is 150 by 150 by 15 feet in size, the material being gravel with a very small proportion of sand. The pebbles are 70 per cent. limestone, the remainder being metamorphic rocks. The upper part of the pit contains large boulders. There is a reserve of 3 acres of this material near the pit. The shore of Lake Ontario at Cobourg consists of sand of the same kind as the Port Hope sand. To the east of the town, the proportion of pebbles increases, and the shore line is marked out by gravel. Between Grafton and Colborne the country becomes sandy, and between Colborne and Brighton there are numerous sandy hills about one mile north from the shore of Lake Ontario. Small sand pits are located in these deposits.

Near Trenton large deposits of sand and gravel are worked in the Trenton mountain (fig. 28), a large hill west of the Trent river and south of the C. P. R. bridge, in Murray township, lots 4 and 5, concession one. The openings are on the side of the mountain, and afford a good section from north to south. The wall is about 150 feet high. At the top there is a layer of gravel from one to six feet thick; next, a sand layer about 15 feet in thickness, and under it about 80 feet of gravel of different sizes. There are some small layers of sand in this gravel; the stratification is horizontal in the main part of the section, but near

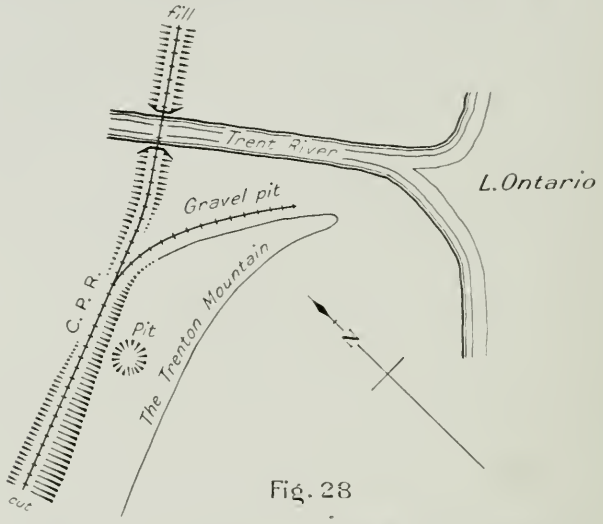

Fig. 28—Location of the Trenton Mountain, Trenton.

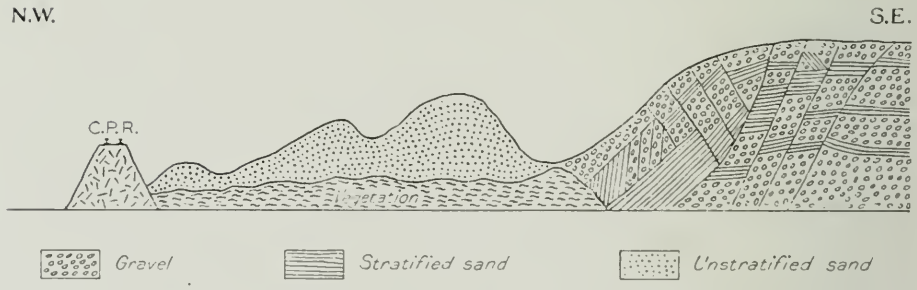

Fig. 29—Diagram of section through the Trenton Mountain.

the northern end there has been some sliding, and several faults separate parts with different dips (fig. 29).

To the north, the formation becomes more sandy; the sand is mostly coarse and sharp, although there are some layers composed of a fine material with a large amount of silt. The coarse sand contains a good proportion of limestone grains, and shows some auto-cementing properties. The gravel is composed mostly of limestone pebbles, but includes also some metamorphic rocks and shales. The ridge of which the Trenton mountain is a part is about 150 yards wide to the south; it runs in a northwesterly direction, nearly parallel to the C. P. Ry. tracks.

A large cutting has been made for the railway roadbed in an east and west direction. Near the central part of this cutting, the ridge has a width of 500 yards. Several pits have been opened on top of the ridge.

Granular metric analysis of sharp sand at Trenton mountain:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	14.50	19.25	22.45	34.75	53.45	97.15	99.50	99.70	99.90

Per cent. of fineness 39.9
Coefficient of uniformity 62.40
Grade ..... No. 5
Real specific gravity 2.908
Apparent specific gravity 1.67
Weight in lbs. per cubic foot .. 104.35
Percentage of voids 42.50

Granular metric analysis of fine silty sand at the Trenton mountain:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.00	0.00	0.10	1.50	4.00	9.95	11.30	13.20	33.40

Per cent. of fineness 91.8
Coefficient of uniformity 86.80
Grade ..... No. 9

Ontario County

Recent deposits of gravel and sand occur in small bays of Lake Ontario, near Whitby and Dunbarton. At Whitby the beach has been drawn on since 1913 to provide building materials for the Provincial Hospital for the Insane. The digging is carried on for eight months a year, with a weekly output of 175 cubic yards. The material is crushed and screened and gives sand, pea gravel with pebbles smaller than three-quarters of an inch, concrete gravel with pebbles from three-quarters of an inch to two inches, and road gravel, larger than two inches, the last being the remnant left from screening. The pebbles are principally of limestone, with a little granite, gneiss, quartzite, sandstone and about two per cent. of shale, the latter very objectionable. The sand is fine, and may be used for mortar, but is not quite sharp enough, and the presence of the shale dust also reduces its quality. Up to June, 1917, the beach had been excavated for a length of 700 feet, a width of 100 feet and a depth of 6 feet. The work is done with a steam shovel (fig. 30) and the yearly output is about 6,000 cubic yards. In the operations most of the western part of the beach has been removed.

There remains some material on the eastern shore of the bay and along the lake shore to the east. The formations near Whitby are mostly clay. Well-borings have discovered quicksand at 14 feet depth in some places, at 25 feet in others. Gravel was struck at a depth of 40 feet about one mile north of Whitby.

Sand pits belonging to Mr. Bonnell and to Mr. Broughton are located east of Whitby, the first at 1½ miles, the second at one-half mile. They supply good sharp sand for building purposes.

There is also a good gravel pit belonging to John Rice, located two miles north of Whitby.

At Dunbarton, the Lakeshore Sand and Gravel Co. is working on the material located in Frenchman bay, for the third season. The daily output is about 400 cubic yards, all brought by boat to Toronto: work is carried on in this plant for five days a week, and eight months a year, making a grand total of 68,000 cubic yards as the yearly output. Three kinds of material, sand, fine and coarse gravels are produced and used for building.

At Pickering on the G. T. Ry. all the sand and gravel used—about 200 cubic yards per year—is taken out of the creek after the spring floods.

Fig. 30—Steam shovel dredging gravel from Lake Ontario, Whitby.

Going north from the shore of Lake Ontario, the recent deposits become thinner, and the country north of the G. T. Ry. is made up mostly of Iroquois clay. Still farther to the north, one approaches the Iroquois sand and gravel ridge along which the Canadian Northern railway was built. This ridge runs in a northeasterly direction to the township of Pickering, passing through concessions one to five. At its western end near Cherrywood it is only three miles from Lake Ontario, but to the east, near Kinsale, it is seven miles north of the lake. The ridge then runs into the township of Whitby West and bends to the southeast, passing through concessions five, four and three, its general direction being from east to west through Whitby East in concession three. Near Taunton it is five miles north of the lake.

Sand and gravel deposits are quite continuous in this ridge through the whole of Ontario county. Numerous pits, most of them gravel pits, have been opened. The character of the gravel is quite uniform along the ridge in this county: the pebbles are subangular to rounded in shape, consisting of about 70 per cent. limestone and 30 per cent. granite and metamorphic rocks. At some places, as in

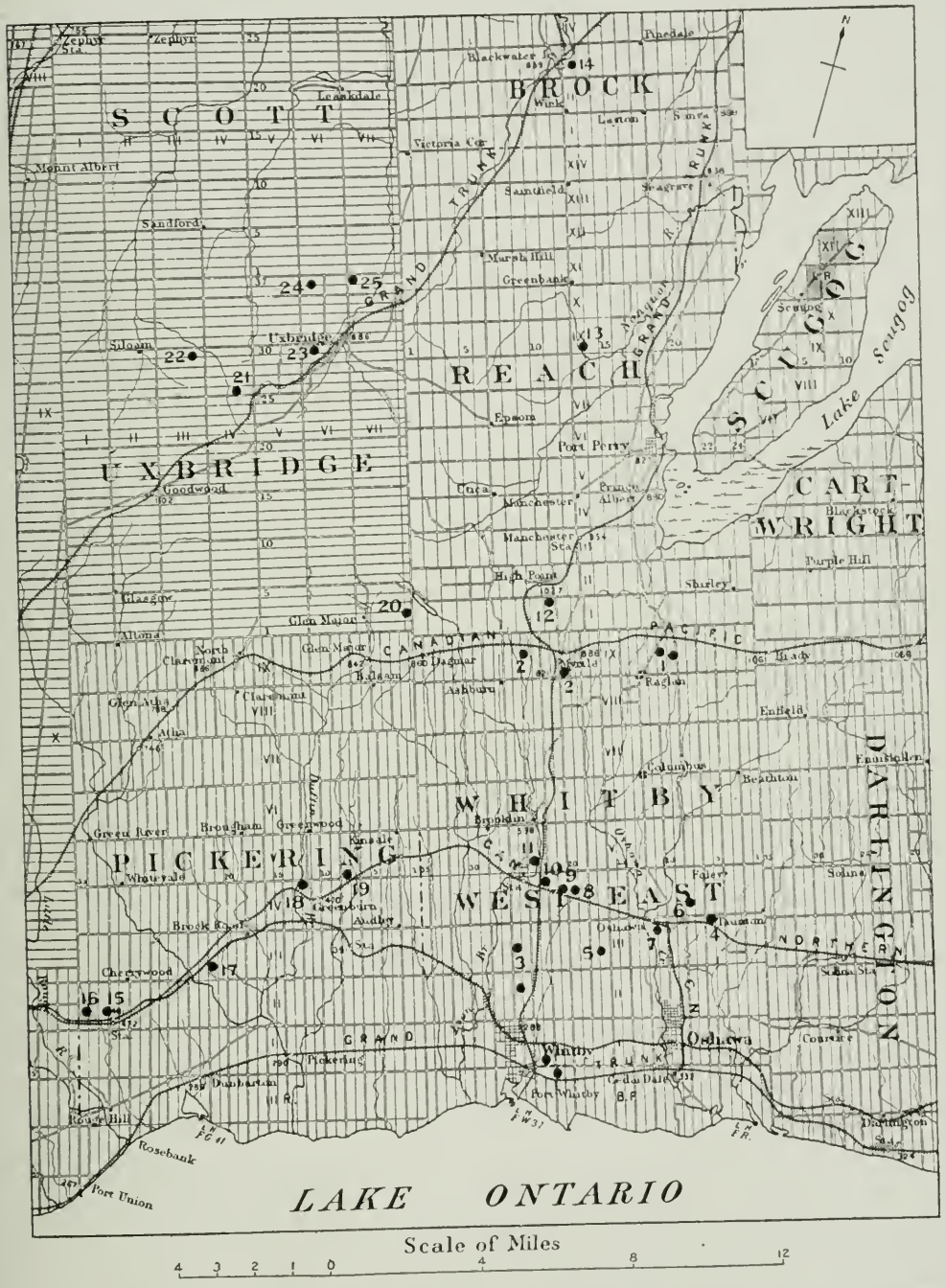

Fig 31—Map of part of Ontario county, showing the location of principal sand and gravel deposits. The numbers refer to the list given in the text.

concessions three and four, Pickering township, near Brock Road, the sand deposits are rather extensive and of great thickness. This material is shipped to Toronto by rail for building purposes. The Iroquois ridge through Ontario county averages more than 300 feet in width. Very large reserves are still available, at least 30,000 by 100 by 2=6,000,000 cubic yards.

North of the Iroquois ridge the region is covered with glacial drift and numerous large boulders. There are many drumlin hills characteristic of the glacial topography. The whole country between the C. N. Ry. and the C. P. Ry. lines is made up of sand; well-borings have shown this formation to extend to a depth of 100 feet before the clay is reached. This sandy formation extends north of the C. P. Ry., as shown in the deep cuttings between Myrtle and High Point. There are large deposits of sand and gravel near Myrtle, Port Perry and Uxbridge. Some moulding sand from a point a little west of the station was used ten years ago by a foundry in Port Perry. One mile south of Uxbridge there is a sandy ridge with numerous pits scattered along it. At the highest point of the ridge some fine white "blow" sand is carried about by the wind, covering the fields and injuring the crops.

To summarize, the eastern part of Ontario county, including the townships of Whitby, Reach, Brock, Thorah, Mara and Rama, has a fair reserve of gravel and sand. There are very few pits in Scugog township. The western row of townships, Pickering, Uxbridge and Scott, have also fairly good reserves of sand suitable for building purposes, and of gravels for ballast and construction work.

The following list gives some details respecting the principal pits in Ontario county (fig. 31):—

No.	Owner	Township, Con. and Lot	Size in ft.	Remarks
1	—— Raglan	Whitby, Con. IX. lot 11-12	..	Road gravel.
2	—— Myrtle	Whitby, Con. IX. lot 20-25	Depth 40	Sand and gravel.
3	Geo. Hurt, Whitby	Whitby, Con. III, lot 26	75 by 75 by 25	Gravel.
4	S. Burgoyne, Oshawa	Whitby, Con. III. lot 6	200 by 75 by 10	Road gravel.
5	Tp. of Whitby and Town of Oshawa	Whitby, Con. III. lot 17		Road gravel.
6	Cement Brick Co., Oshawa	Whitby, Con. IV. lot 9	300 by 100 by 10	Road and concrete gravel.
7	Canadian Northern Ry	Whitby, Con. III, lot 12	1,300 by 120 by 6	Ballast.
8	Canadian Northern Ry	Whitby, Con. IV, lot 20	1,200 by 200 by 15	Ballast.
9	Tp. of Whitby	Whitby, Con. IV, 20-21	500 by 70 by 10	Road and concrete gravel.
10	G. T. Ry.	Whitby, Con. IV, lot 23	1,200 by 250 by 15	Ballast.
11	G. T. Ry.	Whitby, Con. V. lot 24	1,000 by 300 by 12	Ballast.
12		Reach, Con. I and II, lot 10	Depth 40	Gravel.
13	Corporation of Port Perry	Reach, Con. X, lot 13		Sand and gravel.
14	Godson Contracting Co., Toronto	Brock, Con. III, lot 13		Gravel, crushed and screened.
15	C. N. Ry. and C. P. Ry.	Pickering, Con. II, lot 32	400 by 75 by 10	Gravel.
16	C. N. Ry.	Pickering, Con. II, lot 34	700 by 400 by 10	Ballast.
17	Toronto Builders' Supplies Ltd., Toronto	Pickering, Con. III, lot 22	Very deep	Sand.
18	F. L. Green, Greenwood	Pickering, Con. IV, lot 13	300 by 150 by 10	Road gravel.
19	Godson Contracting Co., Toronto	Pickering, Con. V, lot 8		Gravel.
20		Uxbridge, Con. VIII, lot 2		Sand.
21		Uxbridge, Con. IV, lot 26		Sand.
22	C. Hockley, Uxbridge	Uxbridge, Con. III, lot 30		Gravel.
23	Chapman, Uxbridge	Uxbridge, Con. VI, lot 30		Gravel.
24	H. Alford, Uxbridge	Uxbridge, Con. VI, lot 36		Road gravel.
25	H. Gall, Uxbridge	Uxbridge, Con. VII, lot 37		Gravel.

Granular metric analysis of screened sand, Whitby bay:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.00	7.95	16.35	35.55	50.20	88.10	97.30	98.60	99.00

Per cent. of fineness 45.22
Coefficient of uniformity 52.55
Grade ..... No. 5
Real specific gravity 2.824
Apparent specific gravity 1.706
Weight in lbs. per cubic foot .. 106.60
Percentage of voids 39.6

Granular metric analysis of sand, Landshore Sand & Gravel Co., Frenchman's bay:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	0.30	3.10	6.40	16.80	25.70	60.00	93.25	98.40	99.15

Per cent. of fineness 55.2
Coefficient of uniformity 67.55
Grade ..... No. 6
Real specific gravity 2.855
Apparent specific gravity 1.693
Weight in lbs. per cubic foot ... 105.785
Percentage of voids 40.7

Granular metric analysis of fine sand, Landshore Sand & Gravel Co., Frenchman's bay:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	41.55	88.25	98.85	100.00	100.00	100.00	100.00	100.00	100.00

Per cent. of fineness 7.93
Coefficient of uniformity 88.25
Grade ..... No. 1

Oxford County

Large deposits of gravel occur along the Grand Trunk railway between Dorchester in Middlesex county and Beachville in Oxford county. These deposits were extensively worked by the railway for ballast, principally in the neighbourhood of Ingersoll. One of the excavations was two miles long, 75 feet wide and about 20 feet deep. Large excavations of this kind are located north of the railway between Ingersoll and Beachville. There still remain large reserves available.

Around Woodstock there are some deposits of gravel and sand. South of the town there is a sand ridge containing very large reserves. The gravel is generally made up of limestone, with some igneous and metamorphic rocks. The pebbles are as a rule under 2 inches in diameter. The material is sold at an average of 70 cents a cubic yard for delivery in town.

Different grades of sand are found here; they are mostly used for building purposes. Following is a list of the principal pits in the vicinity of Woodstock:

Owner	Location	Size in ft.	Output	Remarks
——Butterfield, Woodstock	Southern part of Woodstock.	40 by 30 by 12	100 yd.	10 ft. sand and little gravel.
C. E. Rapson, Woodstock..	Woodstock.....	20 deep	.....	Sand and cement gravel.
C. E. Rapson, Woodstock ..	Blandford tp., Con. II. lot 17.	60 by 60 by 15		Sand and gravel. Reserve 10 ac.
——Silcox, Woodstock.....	Blandford tp. Con. II, lot 14.	.....	.....	Large reserves of sand and gravel.
——Blair, Woodstock	Blandford tp., Con. II, lot 13.	.....	.....	Large reserves of sand and gravel.
Silvester Keys, Woodstock.	East Oxford tp., Con. III.	.....	.....	Big ridge, about 35 acs. of gravel.

Granular metric analysis of sand from Butterfield's pit, Woodstock:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	1.00	3.75	5.20	12.65	25.45	73.15	88.35	93.20	97.25

Per cent. of fineness	55.55	Apparent specific gravity	1.642
Coefficient of uniformity	62.90	Weight in lbs. per cubic foot...	102.60
Grade	No. 6	Percentage of voids	42.2
Real specific gravity	2.838		

Peel County

There is not much material available in the southern part of this county near the shore of Lake Ontario. In the township of Chinguacousy there are some deposits round Brampton and along the Credit river, and in the northern township of Caledon, some large gravel deposits are found in the Credit river valley near Cataract.

At Brampton, the pits contain mostly sand and gravel, the thickness of the respective layers varying from one pit to another. At the top there are often one or two feet of loam, then 2 to 15 feet sand, and below this again gravel of various grades. There is a little pea gravel, but as a rule the pebbles are rather large and made up of sandstone, limestone, granite and some metamorphic rocks. The pits are deep and the walls stand up well, the gravel showing some auto-cementing power. The principal deposits here form part of a ridge running north and south from lot 5 to lot 12, in concessions one and two, in the eastern part of Chinguacousy.

In the same township deposits along the Credit river are worked near Huttonville, principally for small gravel. This material is sold, as in Brampton, for 25 to 40 cents a yard at the pit.

Large pits were opened near Cataract in the Credit river valley. The gravel is coarse and made up mostly of sandstone, shaly sandstone, igneous and metamorphic rocks. The pits are located on the east bank of the river and mostly

in the concave bends. This gravel was probably brought down by the river during the formation of the valley. The walls of the pits are about 70 feet high. The deposits are extensively worked by steam shovels, the material being used as ballast and road gravel.

The following list gives some details about the pits met with in Peel County:

Owner	Township, Con. and Lot	Size in ft.	Output	Remarks
John Parr, Brampton	Chinguacousy, Con. 2E, lot 5.	30 by 60 by 30	.....	Several other small pits, gravel and sand.
W. B. Markle, Brampton..	Chinguacousy, Con. 2E, lot 6.	150 by 30 by 30	.....	Sand and gravel.
Town of Brampton.....	Chinguacousy, Con. 2E, lot 12	300 by 300 by 30	.....	Road gravel.
Ackroyd, Stanley Mills ..	Chinguacousy, Con. 5E, lot 10	100 by 60 by 15	.....	Pea gravel and sharp sand
John Reid, Huttonville....	Chinguacousy, Con. 4W, lot 5	.....	.....	Small reserves of gravel
J. W. Chesney, Huttonville	Chinguacousy, Con. 5W, lot 5	150 by 100 by 10	Small...	Bucket elevator and screener.
A. Laidlaw, Norval	Chinguacousy, Con. VI, lot 7	.....	.....	Gravel.
.....	Chinguacousy, Con. V, lot 7	.....	.....	Sand.
A. Laidlaw, Norval	Chinguacousy, Con. VI, lot 10	150 by 100 by 5	150 yd..	Cement gravel, mostly limestone pebbles and sand.
Hydro-Electric Com., Toronto	Caledon, Con. III, lot 14 (Cataract)	300 ft. along the Credit R. 70 ft. high.	.....	Coarse gravel.
Canadian Pacific Railway.	Caledon, Con. III, lot 14	500 ft. along the Credit R. 65 ft. high.	.....	Gravel.

Granular metric analysis of sand from John Parr's pit, Brampton:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	1.05	5.85	8.95	36.35	67.05	86.75	94.95	96.85	98.35

Per cent. of fineness 44.87
Coefficient of uniformity 58.10
Grade ..... No. 5
Real specific gravity 2.763
Apparent specific gravity 1.623
Weight in lbs. per cubic foot .. 101.41
Percentage of voids 41.3

Granular metric analysis of gravel from Markle's pit, Brampton:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained.	38.25	58.65	67.35	80.45	87.65	96.30	98.45	98.90	99.55

Per cent. of fineness 19.4
Coefficient of uniformity 58.65
Grade ..... No. 1

Perth County

A great number of deposits are to be found in the southern part of this county near Stratford and St. Marys, in the form of gravel ridges (fig. 32).

To the east of Stratford in the township of North Easthope, two ridges run in a direction from east to west through lots 43 and 44 of concession one. The material is a coarse road gravel, mostly of limestone. It is sold at about 40 cents a yard.

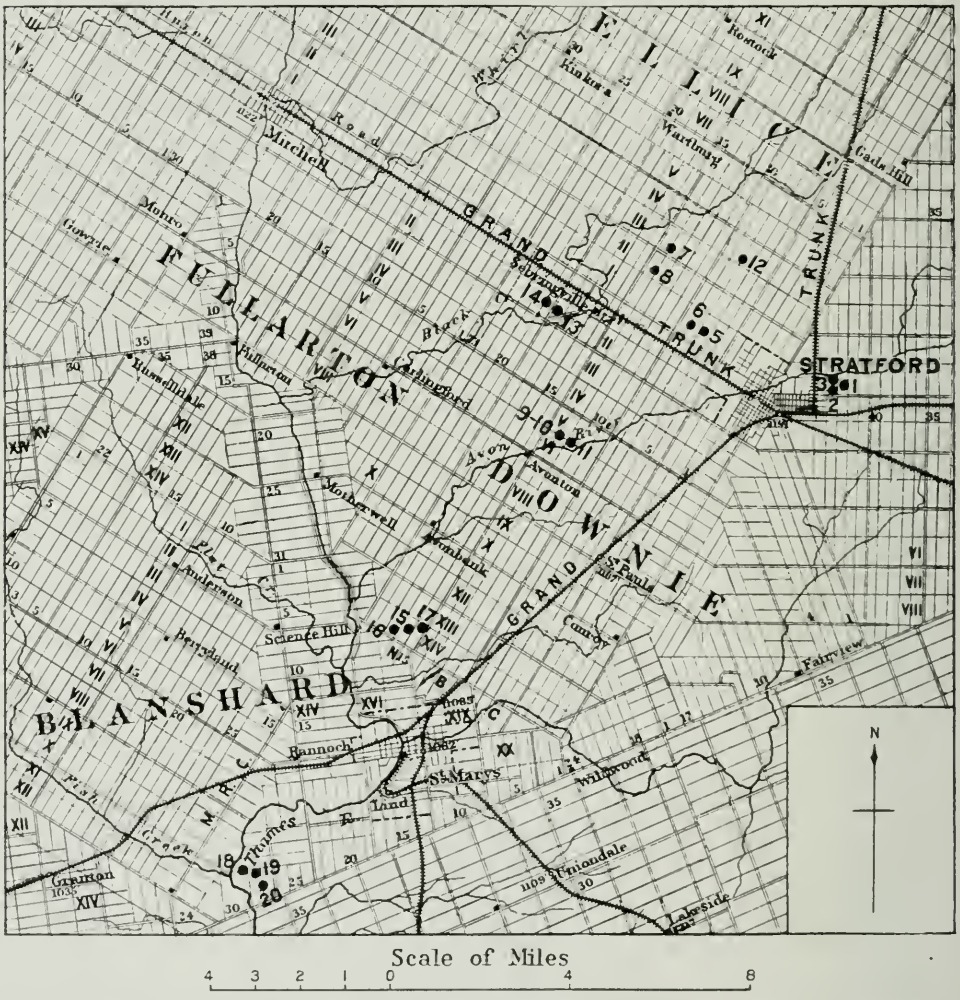

Fig. 32—Map indicating the location of sand and gravel pits in the vicinity of Stratford and St. Marys. Numbers refer to the list in the text.

West of Stratford and about 400 yards north of the Huron road there is a similar ridge running approximately parallel to the road, and at least three miles long. It passes through lots 8 to 12 in concession one of Ellice township and then bends southwards into the township of Downie. A small pit is to be found on the southern side of the Huron road where the ridge crosses the latter. Other ridges are to be seen to the north in Ellice, and some parts of the county are completely overlaid by gravel.

Deposits of gravel of several grades used for road and cement purposes, occur south of Sebringville, on the shore of Black creek. They are probably due to floodings of this creek. The material sometimes contains a little sand. The cement gravel is sold at 50 cents a yard, the road gravel at 12½ cents, and the sand at 50 cents. The pebbles are mostly limestone, but there is a fair proportion of sandstone, as well as some gneiss and granite fragments.

Another gravel ridge extends through concession five, of Downie township, a little northeast of Avonton, on both sides of the Avon river.

In the southern part of Downie, there is a very large ridge containing sand and gravel of fine quality, extending through lots 14, 15, 16 in concession fourteen, and passing into Blanshard township. The sand is sold at 40 cents a yard, the gravel at 35 cents. Much of this material is used in St. Marys for building purposes.

South of St. Marys in concession eight, several large pits are located in lots 28 and 29 on a ridge running north and south. Hills on this ridge indicate where the material is very abundant. They are made up of coarse gravel on top, and cement gravel at the bottom. Stratification is oblique. The pebbles are mostly of limestone, with some sandstone, granite and gneiss. The material is sold at low prices, about 60 cents to $1.00 a cord (12 to 20 cents a yard) for cement gravel and 50 cents a cord (10 cents a yard) for road gravel.

GRAVEL AND SAND PITS IN PERTH COUNTY.

No.	Owner	Township, Con. and Lot	Size in feet	Output	Remarks
1	John Sebben, Stratford	N. Easthope, Con. I, lot 43	10 deep		Road gravel and 3 ft. sand.
2	Henry Kirby, Stratford	N. Easthope, Con. I, lot 44		500 yd.	Road gravel.
3	Henry Kirby, Stratford	N. Easthope, Con. I, lot 44	100 by 100 by 20		Road gravel. Reserve, 4 ac.
4	Wm. McKay, Stratford	Downie	125 by 125 by 20	900 yd.	Road and cement gravel. Coarse sand.
5	Mrs. M. Roadhouse, Stratford	Ellice, Con. I, lot 8.	100 by 125 by 6		Cement gravel.
6	J. R. Schenck, Stratford	Ellice, Con. I, lot 9 .	75 by 75 by 6		Gravel.
7	Chas. Finnegan, Stratford	Ellice, Con. III, lot 14	450 by 300 by 25	600 yd.	Gravel. Reserve 10 acres.
8	Wilmot Frazer, Stratford.	Ellice, Con. II, lot 14	Small pit		Gravel.
9	James Mills Stratford	Downie, Con. V, lot 12	150 by 75 by 15	400 yd.	Gravel. Reserve, 750 by 75 by 15 ft.
10	John Munroe, Stratford	Downie, Con. V, lot 12	500 by 150 by 10		Gravel.
11	Thos. Aitcheson, Stratford	Downie, Con. V, lot 11	150 by 100 by 20		Gravel.
12	Wm. Malloy, Stratford	Ellice, Con. IV, lot 8	300 by 300 by 25	2,500 yd.	Cement and road gravel and sand. Reserve, 50 ac.
13	Geo. S. Litt, Sebringville	Downie, Con. II, lot 18	309 ft. along Black Cr. 15 ft. high	350 yd.	Cement and road gravel, sand.
14	Dillman K. Erb, Sebringville	Downie, Con. II, lot 19	400 by 100 by 20	300 yd.	Cement and road gravel.
15	Edward Betridge .	Downie, Con. XIV, lot 15	75 by 40 by 8	150 yd.	Road and cement, gravel and sand.
16	Gourley	Downie, Con. XIV, lot			Gravel.
17	Wm. White, St. Marys	Downie, Con. XIV, lot 16	100 by 150 by 20	1,000 yd.	Gravel and sand. Reserve, 20 ac.
18	Jas. Harris, St. Marys	Con. VIII, lot 29	450 by 450 by 25	4,000 yd.	Road and cement gravel.
19	Robert Fewster, St. Marys	Con. VIII, lot 28	300 by 150 by 20	750 yd.	Road and cement gravel.
20	Malcolm Conn, St. Marys	Con. VIII, lot 28	150 by 150 by 10		Gravel and sand.

Granular metric analysis of sand from Sebben's pit, Stratford:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	0.10	0.30	0.85	24.35	79.35	92.45	98.85

Per cent. of fineness 67.08
Coefficient of uniformity 78.50
Grade ..... No. 6
Real specific gravity 2.938
Apparent specific gravity 1.524
Weight in lbs. per cubic foot ... 95.225
Percentage of voids 48.1

Granular metric analysis of cement gravel from Edward Betridge's pit, Downie tp.:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	47.60	61.65	68.60	80.55	87.50	95.85	97.50	97.90	98.45

Per cent. of fineness 16.04
Coefficient of uniformity 61.65
Grade ..... No. 1

Granular metric analysis of gravel from M. Harris' pit, St. Marys:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	54.15	64.75	69.80	80.55	87.85	97.10	99.00	99.45	99.80

Per cent. of fineness 16.4
Coefficient of uniformity 64.75
Grade ..... No. 1

Peterborough County

The pits examined in this county are all situated in the city of Peterborough and vicinity. There are some other deposits in the southern part of the county.

The deposits near the city of Peterborough are composed of sand and gravel in alternating layers. The corporation pit, which is located at the north end of the city on the west shore of the Otonabee river, shows on top three yards of fine gravel, underneath which are three feet of sharp sand, then three feet of sandy gravel, then two yards of coarse gravel, and at the bottom large boulders. The excavation, which is about 300 by 60 by 40 feet in size, is part of a ridge, which contains much suitable material; but houses have been built on it so as to render a large proportion of the deposit unavailable.

Just north of the corporation pit there is another pit 250 by 60 by 60 feet in size, which is owned by Mr. Stothart, and shows a similar section. In both pits the gravel contains 75 per cent. limestone, the remainder being granite and metamorphic rocks.

There are several other pits, among which is the Brown pit, 1,000 by 60 by 30 ft. in size, located on the same ridge running parallel to the Otonabee river. This ridge is parallel with the Lakefield road for about one mile, and then turns west at a point about three miles north of the centre of Peterborough.

At the southern end of the city, near the cemetery, J. T. O'Connell owns a sand pit about 200 by 120 by 10 ft. in size, containing layers of coarse sand and pea gravel. The present output of this pit is very small.

Granular metric analysis of sand from T. O'Connell's pit, Peterborough:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	2.55	6.05	11.90	44.30	72.85	92.55	95.55	97.15	98.90

Per cent. of fineness	42.02	Apparent specific gravity	1.611
Coefficient of uniformity	60.95	Percentage of voids	42.5
Grade	No. 4	Weight in lbs. per cubic foot	100.66
Real specific gravity	2.805		

Prescott County

Sand is dug from the shores of the Ottawa river at the northern limit of this county. It is similar in character to the material obtained in the vicinity of the city of Ottawa.

In the neighbourhood of Vankleek Hill there are some gravel and sand deposits. The gravel is composed principally of limestone pebbles. In certain layers the gravel is fine and intermixed with sharp sand in such a proportion that good concrete is obtained in mixing cement with this gravel in the ratio 1 to 7. The reserves of sand and gravel near Vankleek Hill are very large. Details of the principal pits of this region are given below:—

Owner	Township, Con. and Lot	Size in ft.	Output	Remarks
Corporation of Vankleek Hill....	Hawkesbury, W., Con. VI, lot 11...	75 by 75 by 5	.....	Gravel.
D. A. McPhee, Vankleek Hill.....	Hawkesbury, W., Con. VI, lot 10...	400 by 75 by 6	.....	Fine pea gravel. Reserve, 15 ac.
A. J. Cross, Vankleek Hill	Hawkesbury, W., Con. IV, lot 18...	100 by 100 by 15	100 yd.	Sand and cement gravel. Reserve, 1.5 ac.
——Duff, Vankleek Hill, ...	Hawkesbury, W., Con. IV, lot 16...	.....	.....	Sand.

Granular metric analysis of sharp sand from A. J. Cross' pit, Vankleek Hill:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0	0.20	1.75	27.90	65.20	91.30	97.05	98.35	99.15

Per cent. of fineness	46.57	Apparent specific gravity	1.514
Coefficient of uniformity	63.45	Weight in lbs. per cubic foot	94.60
Grade	No. 4	Percentage of voids	43.6
Real specific gravity	2.685		

Prince Edward County

The most extensive deposit of sand in this county, and one of the largest in southern Ontario, is the sandbar south of Wellington. The bar has a direction N.40°W., and is located between Lake Ontario on the west and Yeo lake on the east, making a small strip of ground which is wider to the south. It starts south of Wellington and extends for five miles to Owen Point (fig. 33).

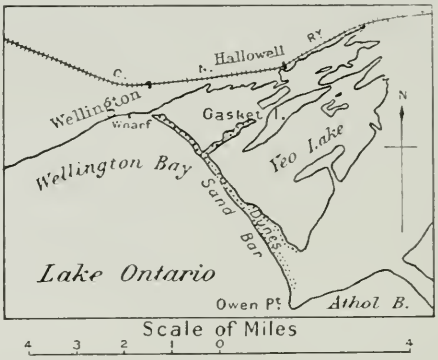

Fig. 33—Sketch indicating the location of the sandbar between Wellington and Owen Point.

At its northern end, that part of the bar above the lake level is only about 25 yards wide. An east-west section in this part is shown in fig 34. On the western side gravel and sand are continuously deposited. The sand is rather sharp, while the gravel is composed of limestone pebbles of varying sizes and a small proportion of granitic material.

The bar remains only 25 yards wide for two miles, then it widens and sand dunes appear in the centre of the bar (fig. 35).

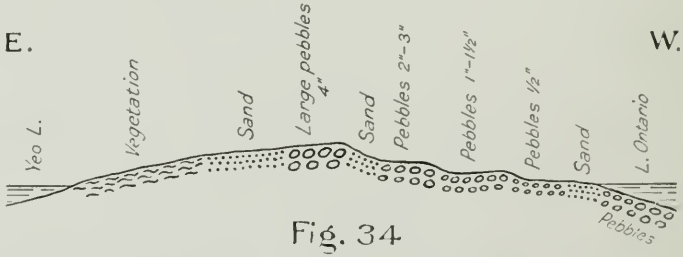

Fig. 34—Section of the northern end of the Wellington sandbar.

The dunes are composed of very white fine sand, while the sand near the shore is coarser and sharper, and contains more ferro-magnesian minerals. The dunes are higher farther south where the bar is wider. About four miles south of Wellington, the dunes have advanced eastwards so as to cover a large area of agricultural ground. Sixty years ago they were close to the shore of Lake Ontario; to-day in the vicinity of Sandbanks they have advanced 500 yards from the shore, and form a ridge extending north and south with an approximate width of 500 yards (fig. 36).

The highest point of this ridge is about 150 feet above the water level.

The amount of sand available is very large. Taking a length of five miles and an average width of 260 yards, the reserve would cover an area of 2,288,000 square yards. With an average height of 20 yards, the total volume may be estimated at 45,760,000 cubic yards.

Fig. 35—Sand beach, two miles south of Wellington.

The dune sand is in general too fine for building purposes, but it has been suggested that some parts could probably be used for making ordinary bottle glass. A microscopical examination of samples taken at different parts of the bar shows that it is composed principally of glassy quartz particles, some of which are covered by rust. Among the other minerals observed were calcite,

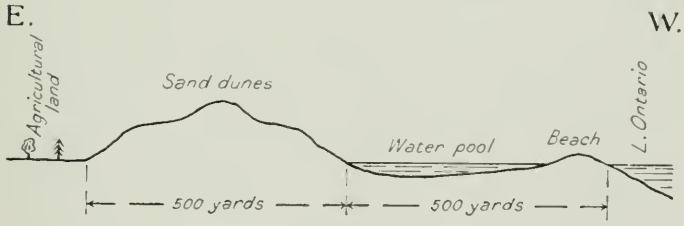

Fig. 36

Fig. 36—Section of the southern end of the Wellington sandbar.

orthoclase, plagioclase, magnetite, rutile, garnet, hornblende and tourmaline. In the shore sand, the proportion of quartz is larger north of the bar than to the south, where garnet and magnetite become more abundant and give to the sand a darker colour. The dune sand is finer grained, and the proportion of heavy ferro-magnesian minerals it contains is lower than in the beach sand, although the coloured minerals account for 5 to 10 per cent. of the whole mass.

In its natural state, this sand seems unsuitable for glass on account of the ferro-magnesian minerals present, but a large amount of the iron-bearing minerals may be extracted by a magnetic separator. Magnetite, garnet, hornblende and

tourmaline are the principal minerals found among the extracted particles. The average proportion of the separated material, in four experiments, amounted to 6.72 per cent.

Chemical analysis of the dune sand of the Wellington bar (1) in its natural state and (2) after magnetic separation gave the following results:

	(1) Per cent.	(2) Per cent.
Silica	59.60	61.69
Alumina	8.52	10.25
Ferric oxide	2.46	0.80
Ferrous oxide	1.64	0.95
Lime	12.61	12.38
Magnesia	1.86	1.33
Potash	2.02	1.62
Soda	2.58	2.72
Water	0.29	0.31
Carbon dioxide	8.36	8.20
Total	99.94	100.25

Norms calculated from the preceding analyses:—

	(1) Per cent.		(2) Per cent.	
Calcite	19.00		18.60	
Orthoclase	11.68		9.45	
Albite	22.01	39.25	23.06	42.24 feldspars
Anorthite	5.56		9.73	
Magnetite	3.71		1.16	
Corundum	....		0.51	
Wollastonite	1.74		....	
Enstatite	4.60		3.30	
Grünerite	0.92		1.19	
Quartz	30.42		33.00	
Water	0.29		0.31	
Total	99.93		100.31	

These figures show that this sand is composed of very mixed materials: feldspars, quartz and calcite are the principal constituents, but the proportion of pure quartz is rather small. The magnetic separation process applied to this sand only separates some magnetite and iron-bearing silicates, and the general composition of the sand is not much improved. For glass-making, the requirements are generally 98 to 99 per cent. of silica, and only traces of iron oxides. These requirements are not met by the sand of Prince Edward county dunes.

Granular metric analysis of sand from central portion of the Wellington dunes:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	0.0	0.0	0.0	0.25	63.75	94.45	100.00

Per cent. of fineness	71.28	Apparent specific gravity	1.575
Coefficient ot uniformity	94.20	Weight in lbs. per cubic foot	98.41
Grade	No. 7	Percentage of voids	46.3
Real specific gravity	2.937		

N.B.—The material remaining on the 200-mesh and passing the 100-mesh is darker than that remaining on the 100-mesh; this is again darker than the material remaining on the 80-mesh.

Granular metric analysis of sand from eastern slope of the dunes:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	0.0	0.0	0.05	3.10	85.60	98.70	99.80

Per cent. of fineness	68.08	Apparent specific gravity	1.558
Coefficient of uniformity	95.6	Weight in lbs. per cubic foot ..	97.35
Grade	No. 7	Percentage of voids	41.8
Real specific gravity	2.823		

N.B.—The small particles contain most of the dark minerals.

Renfrew County

Between Eganville and Golden Lake this country is underlain by granitic rocks covered with forest, the rock at some places being concealed by lenses of brown sand. Similar occurrences exist between Golden Lake and Pembroke. The sand is very often intermixed with pebbles, and grades into gravel. This material has been extensively used by the G. T. Ry. as ballast. West and south of Pembroke the greater part of the area for about two miles is sandy. There is generally some loam at the top, and under it a coarse sharp, brown sand mixed with pebbles, underlain by white sharp sand. It should be noticed that the percentage of limestone pebbles is smaller than usual in the gravel deposits, there being frequently 50 per cent. of granite and metamorphic rocks.

There is an extensive sandy area near Haley on the C. P. Ry. line, and near Olmsted lake. From 6 to 10 miles northwest from Arnprior, there is a sand and gravel beach along the Ottawa river near Castleford and Sandpoint. The sandy formation here covers the limestone outcrops near the river to a height of 50 feet above the present water level.

Arnprior also gets some sand and gravel from pits located in the northwestern end of Carleton county.

SAND AND GRAVEL PITS EXAMINED IN RENFREW COUNTY.

Owner	Location	Size in feet	Remarks
Wm. Markus, Ltd. Pembroke	1 mile S.-W. of Pembroke.	500 by 250 by 40	Brown sand and gravel near top; white sand near bottom.
Johnson Griffith, Pembroke	1 mile S.-E. of Pembroke.	100 by 100 by 8	Concrete gravel. Reserves, 4 acres.
James Stewart, Arnprior.....	3 miles S. of Arnprior...	.....	Road gravel.

Granular metric analysis of brown sand from pit of W. Markus, Ltd., Pembroke:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained ...	32.85	39.20	42.50	54.10	69.30	93.85	97.95	98.75	99.60

Per cent. of fineness	30.2	Apparent specific gravity	1.687
Coefficient of uniformity	39.75	Weight in lbs. per cubic foot ...	105.40
Grade	No. 5	Percentage of voids	38.5
Real specific gravity	2.746		

Russell County

The principal deposits in this county are located at Bear Brook, Bowesville, Brisson, Casselman, Cumberland, and Leonard. The deposits around Casselman, in the township of Cambridge, were visited. These consist of deposits of building sand, moulding sand and gravel, but no extensive work has been done in recent years. The whole district around Casselman is rather sandy, but there is no large market for ordinary sand and gravel in the neighbourhood.

On the other hand, the moulding sand of this region has not been worked, although there are large reserves northwest of Casselman. These moulding sand deposits are well shown on the north side of the G. T. Ry. line between a point about two miles west from Casselman, and the station of South Indian. It occurs as fine grained material in a layer one or two feet thick under the loam.

PITS EXAMINED IN RUSSELL COUNTY.

Owner	Township, Con. and Lot	Size in feet	Remarks
Ad. Rainville, Casselman.....	Cambridge, Con. VI and VII, lot 15	100 by 100 by 30	Principally sand and a little gravel. Reserve, 1.5 acre.
A. F. Durivage, Casselman.....	Cambridge, Con.VIII, lot 7.....	200 by 100 by 6	Sand.
Dieudonne Forgues, Casselman.....	Cambridge.....	90 by 60 by 8	Cement gravel.

Granular metric analysis of sand from Ad. Rainville's pit, Casselman:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0	tr.	0.15	5.05	26.30	72.00	92.50	96.45	99.05

Per cent. of fineness	56.5	Apparent specific gravity	1.589
Coefficient of uniformity	66.95	Weight in lbs. per cubic foot ...	99.29
Grade	No. 5	Percentage of voids	43.2
Real specific gravity	2.795		

Simcoe County

The greater part of this county was covered by the waters of the ancient Lake Algonquin. About three-fifths of the whole area is now covered by surface deposits due to the action of this lake. Several shore lines may be followed through the county. The principal one, known as Algonquin Lake shoreline (fig. 37) enters the southeastern corner of the county through the township of Gwillimbury west and runs in a north-northeasterly direction about parallel to the boundary of the county and the western shore of Lake Simcoe.

At a point about two and a half miles from Big Bay point, the shoreline turns west, passing near Allandale, Colwell and Angus, where it turns again south as far as Beeton, in Tecumseth township. From this point it runs in a more or less straight line about N.40°W. through the townships of Tecumseth, Adjala, Tosorontio, and Nottawasaga, and crosses the county boundary to enter Collingwood township in Grey county. Between Lake Simcoe and the Georgian Bay there are some large islands of Lake Algonquin marked by their old shorelines. In the whole of Simcoe county the Algonquin shore line is between 750 and 775 ft. above sea level.

The preceding facts are of interest for the location of sand and gravel surface deposits. Practically the whole district south of the ancient shoreline consists of good farming lands. Such is the case for the greater part of the townships of Gwillimbury West, Tecumseth, Adjala, Innisfil, and Essa. Good farming land is also found in the northern part of Simcoe county, in the townships of Oro, Vespra and Tiny, which existed during Algonquin times as large islands.

The remainder of the county was covered by Lake Algonquin, and shows to-day extensive deposits of sand, gravel, and clay. This is the case in the greater part of Medonte, Orillia, Tay, Flos, Sunnidale, and Tosorontio townships. It should also be noticed that other shorelines higher than the Algonquin line are marked locally by sand and gravel deposits.

The most abundant deposit of Lake Algonquin is a brownish red or reddish brown sand, too fine in size to be of economical value, as shown by the granular metric analysis. It can be well seen in the cuttings of the Nottawasaga river in Tecumseth and Essa townships. The upper part of the section is this reddish sand: under it comes some finer white sand approaching quick sand, and at the bottom of the valley there is some silty, impermeable clay. Borings for water at Camp Borden, in Essa township, showed a similar section: under the clay the borings struck a formation of sand and gravel containing water coming from Lake Simcoe, altitude 718 feet, and well filtered during its underground course. In some borings made at Camp Borden 45 feet of sand were found below the 630 feet altitude and over the clay.

To get a general view of these surface deposits, a trip was begun from Coldwater, in Medonte township, taking the C.P.Ry. in a southwesterly direction. Near Coldwater there is some sand. Gravel excavations and cuttings occur near Eady station; the brown ferruginous sand is very abundant near Carley station, where it extends over miles of the country. It can be followed for ten miles along the C.P.Ry. tracks, being sometimes mixed with pebbles and used for ballast. This sand formation is also very characteristic near Craighurst, in the southwest corner of Medonte township. It runs also over Vespra township: the sand shows a

Fig. 27—Map of Lake Simcoe showing portions of the counties of Simcoe, York and Ontario. The approximate location of the shore line of ancient Lake Algonquin is indicated by a heavy line.

thickness of more than 100 feet in a big ravine, north of Midhurst station. South of Vespra township there is the ancient channel between a large island and Lake Algonquin shore; here the pebbles become more abundant, and large deposits of gravel occur southeast of Utopia station, near the boundary of Essa township. The region around and west of Angus is very sandy: the greatest part of this surface sand is a fine dune sand.

Sand dunes form a ridge near the southern boundary line between Sunnidale and Tosorontio townships. An extensive area covering parts of Essa, Tosorontio, Adjala and Tecumseth townships is part of a large bay of ancient Lake Algonquin. This bay has been completely filled by sand, and at present forms a country made up of large pine plains and extensive barren sandy grounds. It is in this region that Camp Borden is located.

Near Orillia, there are large deposits of sand and gravel between the present shore of Lake Couchiching and the shore line of a large ancient island of Lake Algonquin. This line runs about parallel to the western shores of Lake Simcoe and Lake Couchiching from Barrie to the northern end of Lake Couchiching. Lake Simcoe is, in fact, a remaining part of the channel between this large island and the shore of Lake Algonquin. Similar formations are found near Barrie and Allandale.

The region near Collingwood, in the northwest corner of Simcoe county, is a good example of recent detrital formation. Collingwood is on Nottawasaga Bay, near the southern point of Georgian Bay. To the east of the town, there is a gravel area still in formation, as can be seen along the creeks. The bottom of these creeks is made of shaly Ordovician limestone, covered by very angular pebbles of the same material. In summer time many of the creeks are dry, but during the winter the lake and the creeks carry this gravel over the adjoining area about six miles in an east-west direction and one mile in a north-south direction. The depth is variable and generally not more than four feet. The gravel is not of first-class quality, and only small pits have been opened in it. Going east the gravel turns gradually into sand. On the beach, six miles from Collingwood, the sand still contains some gravel, but farther east it becomes a characteristic beach sand extending ten to twelve miles along the shore to the mouth of the Nottawasaga river. The sand contains some magnetite and garnet grains, and is used for building purposes. The beach, not covered by vegetation, is at present 30 to 50 feet wide. It was from 150 to 200 feet some years ago, when the level of the lake was much lower.

Granular metric analysis of sand near the surface, Camp Borden:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	0.0	0.0	tr.	1.70	23.60	57.80	96.00

Per cent. of fineness	80.1	Apparent specific gravity	1.527
Coefficient of uniformity	72.40	Weight in lbs. per cubic foot	95.41
Grade	No. 8	Percentage of voids	48.3
Real specific gravity	2.958		

Granular metric analysis of silty sand, Camp Borden:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	0.0	0.0	tr.	1.25	2.00	5.70	41.50

Per cent. of fineness 94.39
Coefficient of uniformity 94.30
Grade ..... No. 9

Granular metric analysis of sand from Nottawasaga bay, seven miles east of Collingwood:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	0.0	tr.	tr.	13.80	82.95	98.10	99.95

Per cent. of fineness 67.24
Coefficient of uniformity 84.30
Grade ..... No. 7
Real specific gravity 2.864
Apparent specific gravity 1.633
Weight in lbs. per cubic foot ... 102.04
Percentage of voids 42.9

Stormont County

Deposits of sand and gravel are abundant in this county (fig. 38) as shown by the numerous excavations. These pits are mostly not very large, although they have a great quantity of material in reserve; the demand, however, is small. The deposits are generally in the form of irregular lenses of sand and gravel intermixed; the sand is rather sharp and is sometimes black in colour from the presence of the limestone grains. The gravel is generally sandy, 60 to 90 per cent. of the pebbles being composed of limestone, the remainder being granitic material. The size is variable, but the average is a fine gravel, large pebbles and boulders occuring only on top of the deposits. These materials are sold at various prices, but on the average the pit owners ask 50 cents a yard for building sand or cement gravel, and 25 cents a yard for road gravel. The writer visited a number of pits located near the southern boundary of the county, and others on both sides of the New York and Ottawa railway. A list of the principal excavations follows:—

No.	Owner	Township, Con. and Lot	Size in ft.	Output	Remarks
1	Ephraim Aube, Berwick	Finch, Con. VII, lot 18	120 by 50 by 10	200yd.	Nearly all building sand.
2	Henri Canneer, Berwick	Finch, Con. V, lot 20.	40 by 25 by 8	100yd.	Road gravel. Reserve, 0.5 ac.
3	Alfred Casselman, Berwick	Finch, Con. VI, lot 17.	125 by 125 by 8	100yd.	Road and cement gravel and sand. Reserve, 1.5 ac.
4	Guy Empey, Finch	Finch, Con. IV, lots 15, 16	(30 by 60 by 5) (100 by 40 by 6)	.....	Two gravel pits. Reserve, 5 ac.
5	Michael Godard, Crysler	Finch, Con. IX, lot 20	500 by 125 by 12	300yd.	Gravel and sand. Reserve, 10 ac.
6	Wesley Hume, Northfield	Finch, Con. V, lot 19.	100 by 25 by 12	.....	Road gravel. Reserve, 1 ac.
7	Ronald McMillan, Finch	Finch, Con. IV, lot 19.	150 by 100 by 7	300yd.	Road and cement gravel. Reserve, 2 ac.
8	Wm. Bowles, Newington	Osnabruck, Con. VIII, lot 28.	175 by 100 by 8	.....	Sharp sand and pea gravel. Reserve, 2 ac.
9	J. Joint, Newington	Osnabruck, Con. VIII.	150 by 100 by 4	.....	Road gravel. Reserve, 2 ac.
10	Jas. Winter	Osnabruck, Con. VIII,	150 by 100 by 9	.....	Sand and gravel. Reserve, 7 ac.
11	Albert Aimable, Moulinette	Cornwall	.....	.....	Gravel.
12	Thos. Cleary, Mille Roches	Cornwall, Con. I, lot 28	120 by 60 by 10	300yd.	Sand and gravel. Reserve, 1.5 ac.
13	Alexander Day, Mille Roches	Cornwall, Con. III	60 by 60 by 8	.....	Road and cement gravel; sand.
14	Hugh McGillis, Harrison Corners	Cornwall	120 by 120 by 7	.....	Coarse gravel. Large reserves.
15	Herbert Mattice, Wales	Cornwall, Con. II, lot 34	125 by 125 by 20	.....	Gravel and sand of various grades. Reserve, 2 ac.
16	Wm. Murphy, Wales	Cornwall, Con. II, R. 5, lot 36.	500 by 100 by 9	.....	Gravel. Reserve, 8 ac.
17	Geo. Murray, Cornwall	Cornwall, Con. VI, lot 31	150 by 100 by 12	.....	Coarse gravel.
18	Howard Winters, Mille Roches	Cornwall, Con. III, lot 24	500 by 250 by 15	250yd.	Fine gravel. Reserve, 7 ac.
19	Cory Woods, Moulinette	Cornwall	.....	.....	Gravel.

Granular metric analysis of sand from Michael Godard's pit, Crysler:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	0.10	0.30	0.50	8.90	42.05	65.20	90.40

Per cent. of fineness	76.95	Apparent specific gravity	1.568
Coefficient of uniformity	56.30	Weight in lbs. per cubic foot	97.975
Grade	No. 7	Percentage of voids	43.04
Real specific gravity	2.753		

Granular metric analysis of fine sand from H. Mattice's pit, Moulinette:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	0.0	tr.	tr.	0.10	0.50	7.45	61.25

Per cent. of fineness	92.3	Apparent specific gravity	1.434
Coefficient of uniformity	92.55	Weight in lbs. per cubic foot	89.60
Grade	No. 9	Percentage of voids	54.7
Real specific gravity	3.168		

Victoria County

The shoreline of the glacial lake Algonquin passes through the townships of Dalton, Carden, Bexley, Fenelon, Somerville, and Eldon. The usual deposits of sand and gravel occur along this line, for instance, near Argyle, Kirkfield, Baddow, and Fenelon Falls.

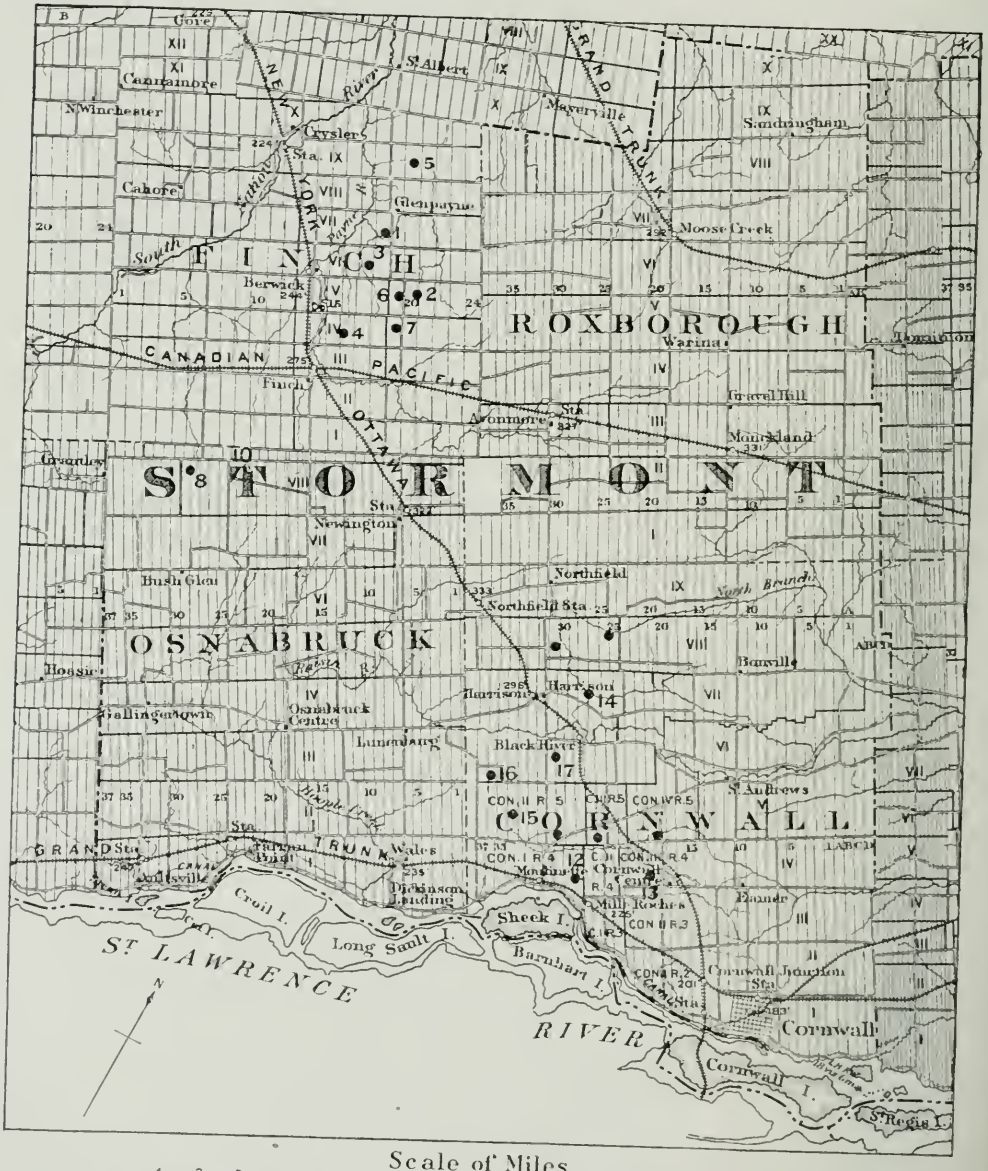

Fig. 38—Map of Stormont county, showing the principal sand and gravel pits. Numbers refer to the list given in the text.

In the township of Fenelon there are extensive deposits of sand of different grades on the McCormick hills, about three miles west from Fenelon Falls. The material is sharp, and contains a large amount of limestone grains. This deposit covers about 400 acres.

The area east of Fenelon Falls along Sturgeon lake, in the townships of Fenelon and Verulam, is part of the ancient channel connecting Algonquin lake and Iroquois lake. This channel is known as Algonquin river and follows the chain of lakes in this district and the Trent valley. Numerous fluviatile deposits of sand and gravel occur along this line.

North of Burnt River, in Somerville township, the country is very sandy, and consists principally of calcareous sand originating from the weathering of the underlying limestones. The deposits extend to the south of Burnt River, where there is also some limestone gravel.

This line of deposits also occurs in Verulam township, where there are numerous beds of sand and gravel. Along the Bobcaygeon-Lindsay road several pits have been opened.

In the township of Ops a ridge of gravel west of Lindsay runs in a northeast-southwest direction and passes through lots 18, 19, 20 and 21 of concession 4. It is about one and a half miles from the town of Lindsay, and several pits have been opened upon it. The depth is generally about 10 feet. About 70 per cent. of the gravel is composed of limestone pebbles. The large stones found on top of the deposits are used for foundation work. Some sand with bonding power sufficient to make good moulding sand was found on top of this ridge.

SAND AND GRAVEL PITS IN VICTORIA COUNTY.

Owner	Township, Con. and Lot	Size in feet.	Remarks
Wm. Weese, Lindsay	Ops, Con. IV, lot 18S	150 by 60 by 10	Gravel. Reserve, 10 ac.
Patrick McGuire, Lindsay	Ops, Con. IV, lot 18N		Gravel.
Miller, Lindsay	Ops, Con. IV, lot 19		Gravel.
Patrick Murphy, Lindsay	Ops, Con. IV, lot 20		Gravel.
Lindsay Corporation, Lindsay	Ops, Con. V, lot 23		Road gravel
Grand Trunk Ry	Fenelon		Gravel.
G. H. Brandon, Fenelon Falls	Fenelon		Sand.
Fenelon Council	Fenelon, McCormick Hills	200 by 40 by 15	Sand.
R. Hawkins, Woodville	Eldon, Con. III, lot 17		Sand and gravel.
Alex. Morrison, Kinmount	Somerville, near Kinmount		Sand.
Somerville Township	Somerville, Con. I, lot 22		Gravel.
Thos. Hodgson, Burnt River	Somerville, Con. V, lot 12	100 by 30 by 8	Sand and gravel.
John Rich, Bobcaygeon	Verulam	100 by 75 by 10	Sand and gravel. Reserve, 1 acre.
Thos. Kettle, Bobcaygeon	Verulam		Sand and gravel.
C. D. Logan, Bobcaygeon	Verulam		Sand and gravel.
R. W. Wilson, Omemee	Emily		Gravel.
McConnell, Omemee	Emily		Gravel.
Frank Duwell	Fenelon, McCormick Hills	500 by 125 by 10	Sand.

Granular metric analysis of sand from F. Duwell's pit, McCormick hills:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	2.10	9.60	16.55	37.70	52.85	82.05	93.50	96.25	98.35

Per cent. of fineness 45.67
Coefficient of uniformity 44.35
Grade ..... No. 5
Real specific gravity 2.837
Apparent specific gravity 1.664
Weight in lbs. per cubic foot .. 103.973
Percentage of voids 41.3

Granular metric analysis of gravel from W. Weese's pit, Lindsay:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	57.20	66.60	73.95	87.30	92.30	96.75	98.15	98.70	99.30

Per cent. of fineness 14.42
Coefficient of uniformity 66.60
Grade ..... No. 1

Fig. 39—Sand and Supplies, Ltd., Ayr.
View of the pit and bucket elevator.

Waterloo County

In the vicinity of Kitchener, Preston, Galt and Ayr the county is hilly, and there are several gravel ridges, a few of which have been worked. The most important pits are those of Sand and Supplies, Ltd., of Toronto, near Ayr. This

concern owns a large pit situated in a ridge of hills one and a half miles northeast of Ayr (fig. 39). The excavation covers at present a surface of 600 by 250 feet, the depth varying between 15 and 60 feet. The upper 15 feet of the high wall are gravel; under it there are sands of varying character, sometimes mingled with pebbles. At certain places 4 feet of clay occur near the top. The excavating is done by a digger elevator with buckets and screeners, producing materials of different grades. A car of 80,000 lb. capacity is filled in nearly 20 minutes.

Granular metric analysis of sand from Sand and Supplies Co., Ltd., Toronto (Ayr pit):—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.30	1.10	8.40	22.80	78.30	96.90	98.95	99.60

Per cent. of fineness	54.85	Apparent specific gravity	1.634
Coefficient of uniformity	74.10	Weight in lbs. per cubic foot	102.099
Grade	No. 6	Percentage of voids	41.4
Real specific gravity	2.791		

Welland County

Sand deposits are still in formation along the beaches of Lake Erie between Port Colborne and the mouth of the Niagara river. The material is worked on a large scale and is used for building purposes in Canada and in the United States.

Welland county lies completely south of the Niagara escarpment, on a plateau at an altitude of about 550 feet. On this plateau there are several buried channels and valleys, representing ancient connecting lines between Lake Erie and Lake Ontario. These valleys, like the present Niagara valley, were cut through the Niagara limestones and Medina shales. They are now completely filled with drift, sand, and gravel. The most important gravel pits of this county are located in these buried valleys. In such pits, irregular, oblique stratification is not rare. Gravel and sandbeds alternate, some parts of the valley being completely occupied by sand, others containing more gravel. The sand comprises a variety of grades, some parts being good sharp building material. The gravels are mostly of small limestone pebbles, with a little sandstone; the average gravel is a good auto-cementing material for concrete work. Deposits of this kind have been worked around Fonthill, Stamford, and Niagara Falls.

The concerns working in Welland county are mostly large and well equipped, this being the case both for those dredging sand out of Lake Erie and those working gravel pits. The material is sold at about 50 cents a yard. Some moulding sand is found on top of the buried valleys.

SAND AND GRAVEL PRODUCERS, WELLAND COUNTY

Owner	Location	Size in feet.	Output.	Remarks
Confederation Sand and Gravel Co., St. Catharines	Mouth of Niagara R.		100,000 yd.	Sand dredged out of Lake Ontario
Empire Limestone Co., Buffalo	Lake Erie shore		100,000 yd.	Sand dredged out of Lake Erie..
Conlon, St. Catharines	Fonthill	180 by 90 by 40 100 by 120 by 40		Two pits. Sand and gravel.
Clifton Sand and Gravel Co., Toronto.	Stamford	450 by 600 by 75		Sand. Reserve, 50 acres.
Ontario Sand Co., Niagara Falls	Stamford tp.	300 by 400 by 15	12,000 yd.	Gravel and sand. Reserve, 39 acs.
Stamford Sand Co., Niagara Falls	Stamford tp	500 by 300 by 75		Sand and gravel.
Standard Gravel Co., Niagara Falls	Stamford tp	200 by 200 by 15	Daily output in 1917, 100 yds.	Sand and gravel. Reserve, 6 ac.

Granular metric analysis of sand from the Ontario Sand Co.'s pit, Niagara Falls:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained....	13.0	20.45	25.50	49.60	68.85	90.05	94.95	96.25	97.75

Per cent. of fineness	38.2	Apparent specific gravity	1.743
Coefficient of uniformity	43.35	Weight in lbs. per cubic foot	108.910
Grade	No. 4	Percentage of voids	38.8
Real specific gravity	2.847		

Granular metric analysis of gravel from the Standard Gravel Co.'s pit, Niagara Falls:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained ...	35.35	45.75	50.85	61.65	70.75	93.40	98.20	98.85	99.35

Per cent. of fineness	27.3
Coefficient of uniformity	45.75
Grade	No. 1

Wellington County

The pits examined in this county were near Guelph and Erin. In the southern part of Guelph there is a ridge about 100 feet west of the Waterloo road, containing road and cement gravel, moulding sand, brick sand, and building sand. This deposit extends over a large area, and important reserves are still available. In one of the pits there were about 20 feet of sand on top, over the gravel; and borings have shown

this gravel to be 80 feet in thickness, overlying the limestone. The sand, which shows oblique stratification, is of good quality for making mortar and for other building purposes. In some places there are 4 feet of moulding sand. This material is valuable, and is sold at $2.50 a yard, while gravel and ordinary sand sell at $1.50 per yard, delivered in Guelph.

The amount of gravel and sand found in the neighbourhood of Erin is very large, and some important concerns are now in operation. The gravel, which usually contains 60 per cent. pebbles and 40 per cent. sand, is screened to provide different grades. The large pebbles are sometimes crushed to produce finer material.

SAND AND GRAVEL PRODUCERS IN WELLINGTON COUNTY.

Owner	Location	Size in feet	Output	Remarks
Agnes Haggerty, Guelph	Waterloo Rd., Guelph	15 by 10 by 12	.....	Gravel pit opened in 1916.
A. McCannell, Guelph	Waterloo Rd	150 by 150 by 20 150 by 75 by 15	2,000 yd.	Gravel pit. Sand pit. Reserves, 40 acres.
Dr. Gear, Erin	Erin tp., Con. X, lot 15	75 by 60 by 12	350 yd.	Gravel and sand sold at 10c. per yd. at the pit.
Rocsand Co., Erin	Erin tp., Con. X, lot 16	500 by 350 by 20	Daily output in 1917, 300 cu. yd.	Gravel and sand, steam shovel and screening plant. Reserve, 20 acres.
C. P. Ry., Erin	Erin tp., Con. X, lot 16	1,000 by 200 by 15	.....	Ballast.
Construction and Paving Co., of Ont., Toronto.	Erin tp., Con. XI, lot 15	300 by 100 by 18	8,500 yd.	Gravel and sand.
J. Hamilton, Erin	Erin tp., Con. X, lot 15	Depth, 35 ft. gravel	Not worked	Gravel and sand. Reserves, 40 acres.

Granular metric analysis of sand from Rocsand Company's pit, Erin:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained ...	0.35	2.65	5.95	18.65	41.20	92.45	97.20	98.05	98.80

Per cent. of fineness	49.4	Apparent specific gravity	1.636
Coefficient of uniformity	73.80	Weight in lbs. per cubic foot ..	102.22
Grade	No. 5	Percentage of voids	44.2
Real specific gravity	2.935		

Granular metric analysis of gravel from Rocsand Co., Erin:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained ...	57.85	67.40	72.10	81.10	88.90	97.85	99.30	99.50	99.70

Per cent. of fineness	15.14
Coefficient of uniformity	67.40
Grade	No. 1

Wentworth County

This county, with Hamilton as its principal city, is crossed by the shoreline of ancient Lake Iroquois (fig. 40). This shoreline is located at an average of about two and a half miles inland from the present shore of Lake Ontario, and lies close to and parallel with the Niagara escarpment. Several deposits of sand and gravel occur along this line, and are valuable sources of supply for Hamilton.

In the region south of Bartonville, in the townships of Saltfleet and Barton, moulding sand occurs as a surface deposit, and this material is used in the foundries of Hamilton and of Ontario in general. All grades of moulding sand, from very fine brass sand to coarse pipe sand, have been found in this region.

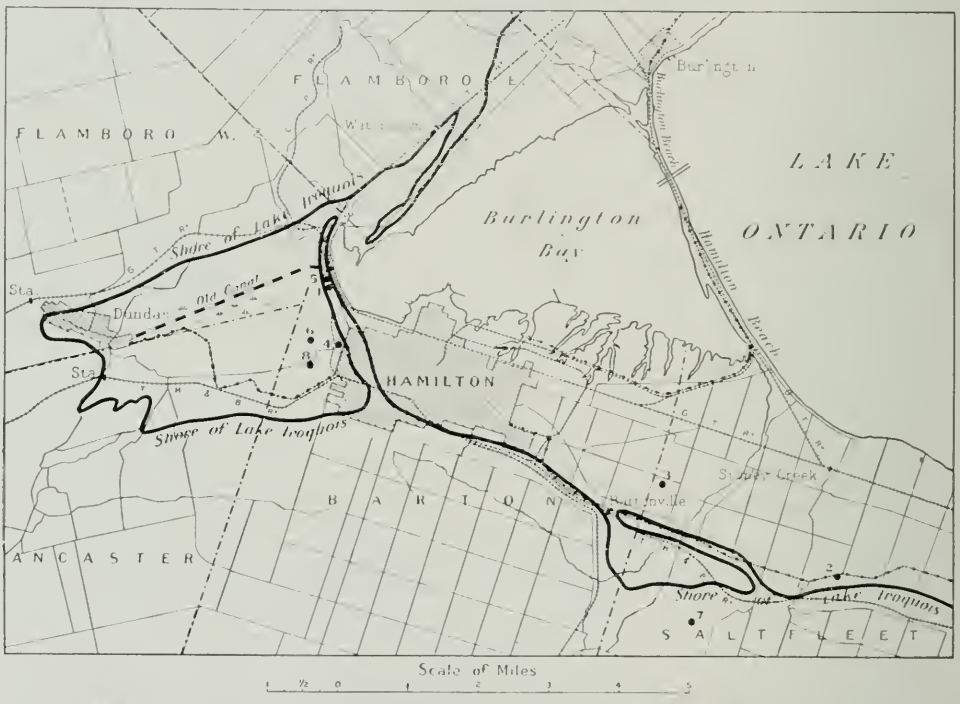

Fig. 40—Map of Hamilton and vicinity, showing location of the principal sand and gravel deposits, also the shore line of ancient Lake Iroquois. Numbers refer to the list given in the text.

There are also very large deposits west of Hamilton, on the area covered by the ancient bay that terminated Lake Iroquois to the west. These deposits, which at some places consist of alternate layers of clay, sand, and gravel, have been largely worked by brick plants.

Some layers of gravel are cemented by calcite; others consist of sandy gravel, from which by crushing the larger boulders and screening, the following products are obtained: coarse gravel, medium gravel, crushed stone for roadwork, pea gravel for concrete, medium sand, brick sand, and core sand. At the Armstrong Supply Co.'s pit at Hamilton, for instance, there are about 160 feet of gravel and sand before the water level is reached. The screening diagram of this concern indicates how the material is prepared for the market (fig. 41).

A large sandbar extends east of Hamilton in a north-south direction across Burlington bay, connecting Hamilton and Burlington. The southern part is known as Hamilton beach, the northern as Burlington beach. This bar is covered by cottages, railways, etc., and forms an important natural bridge. It is controlled by the Burlington Beach Commission. A little sand has been taken out of the lake in the neighbourhood. The average material sells at prices ranging from 70 cents to one dollar a yard at the pit. Moulding sand is sold at about one dollar per ton.

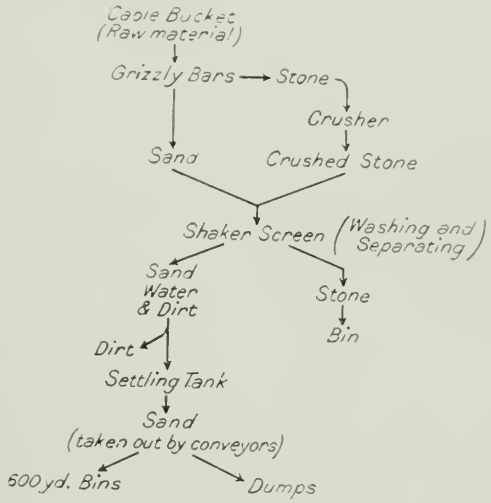

Fig. 41—Screening diagram of Armstrong Supply Co., Hamilton.

SAND AND GRAVEL PRODUCERS, WENTWORTH COUNTY.

No.	Owner	Location	Size in ft.	Output	Remarks.
1	Armstrong Supply Co., Hamilton	Western end of Burlington bay	Depth of pit, 80 ft.		Sand and gravel. Reserves, 18 ac.
2	W. Barnes, Hamilton	Stoney Creek			Gravel and some moulding sand.
3	Barton Sand & Gravel Co., Bartonville	Barton tp., Con. III, lot 1	30 deep	8,000 yd.	Sand & gravel. Plant of 400 yds daily capacity. Reserve, 12 ac. (fig. 42)
4	Geo. Frid Brick Co., Hamilton	Northwest of Hamilton	50 by 50 by 30	26 yd. per day	Sand and gravel. (fig. 43)
5	Hamilton Sand and Gravel Co., Hamilton	Junction Cut, Hamilton	350 by 150 by 40	60 yd. per day (10,000 yds)	Gravel and sand. (fig. 44)
6	Ollmann Bros., Hamilton	Northwest end of Hamilton, near Dundas Road	500 by 300 by 40	2,000 yd.	Sand and gravel. Reserve, 8 ac.
7	O. Quigley, Hamilton	Saltfleet tp., Con. IV and V, lot 30	Depth, 6 ft.	10,000 yd.	Moulding sand. Reserve, 75 ac.
8	R. Tope, Hamilton	Dundas Rd., Barton tp. Con. II, lot 20	100 by 50 by 30		Gravel (fig. 45)

Chemical analysis of pipe moulding sand, O. Quigley, Hamilton:—

	Per cent.
Silica (SiO_2)	80.42
Iron (Fe)	0.05
Iron oxide (Fe_2O_3)	5.423
Magnesia (MgO)	1.48
Alumina (Al_2O_3)	5.10
Lime (CaO)	3.12
Carbon dioxide (CO_2)	4.05
Total	99.643

Fig. 42—Barton Sand and Gravel Co's. pit, Bartonville.

Chemical analysis of machinery moulding sand, Quigley pit, Hamilton:—

(Analysis by W. K. McNeill, Provincial Assayer.)

	Per cent.
Silica	74.42
Alumina	10.37
Ferric oxide	2.61
Ferrous oxide	2.22
Lime	2.76
Magnesia	1.08
Potash	1.72
Soda	2.36
Water	1.65
Carbon dioxide	1.00
Total	100.19

The bonding power of this material is due to the high percentage of alumina and iron oxides.

Norm calculated from the preceding analysis:—

Calcite		2.30	
Orthoclase	10.01		
Albite	19.91	37.15	feldspars
Anorthite	7.23		
Corundum		2.04	
Magnetite		3.71	
Enstatite		2.70	
Grünerite		1.98	
Quartz		48.60	
Water		1.00	
Total		99.48	

The corundum and magnetite indicate the presence of kaolinite or clay mixed with iron oxides, the cause of the moulding qualities of the sand.

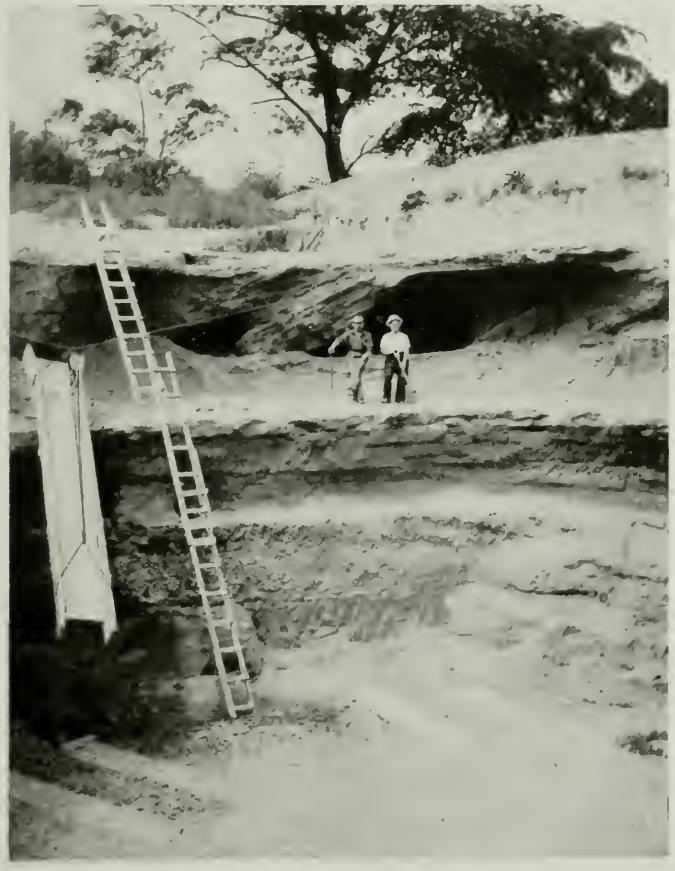

Fig. 43—Frid gravel pit, Hamilton.

Fig. 44—Hamilton Sand and Gravel Co's. pit and screening plant.

Fig. 45—Tope gravel pit, Hamilton.

Granular metric analysis of washed sand from Armstrong Supply Co., Hamilton:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.05	4.95	10.00	24.30	32.05	68.05	94.00	98.60	99.10

Per cent. of fineness	52.10	Apparent specific gravity	1.645
Coefficient of uniformity	61.95	Weight in lbs. per cubic foot	102.786
Grade	No. 6	Percentage of voids	42.1
Real specific gravity	2.841		

Granular metric analysis of sharp sand from Hamilton Sand and Gravel Co., Hamilton:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.20	0.70	1.45	4.65	11.75	71.75	97.55	99.25	99.60

Per cent. of fineness	57.08	Apparent specific gravity	1.511
Coefficient of uniformity	85.80	Weight in lbs. per cubic foot	94.413
Grade	No. 6	Percentage of voids	48.4
Real specific gravity	2.933		

Granular metric analysis of pea gravel, from Armstrong Supply Co., Hamilton:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	89.69	99.85	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Per cent. of fineness	1.17
Coefficient of uniformity	99.85
Grade	No. 1

York County

The shorelines of Lake Algonquin and Lake Iroquois which pass across this county are rich in deposits of gravel and sand. From an economic standpoint, the deposits of the Lake Iroquois beach are the more important, on account of their proximity to the city of Toronto. The whole area between the Iroquois shoreline and Lake Ontario is covered by Iroquois beach materials, principally sand (fig. 46).

The greater part of Toronto lies on Iroquois sand, and while some large pits are still working inside the city limits, most of them are nearing exhaustion, as the surrounding buildings prevent the extension of the worked area.

On the southern side of Bloor street west, about 250 yards west of Dundas street, there is an outcrop of sand, 10 feet above the street level. Under the soil there are 3.5 feet of moulding sand, then a small gravel bed, and under it ordinary Iroquois building sand.

West of Toronto, and about two miles east of the Humber river, there are some small gravel and sand pits.

Fig. 46—Toronto and vicinity, showing location of principal sand and gravel pits. The numbers refer to the list given in the text.

Most of the sand and gravel supply of Toronto comes from the suburbs and from the surrounding district. Large sand and gravel bars were formed during Iroquois times east and west of the present city limits; the eastern bar, which is the more important, passes through York and Birch Cliff, while the western bar passes near West Toronto station and Lambton Mills. These bars were built up in the same way as Toronto Island is now being formed. This recent bar is not worked, the island being used as a summer resort.

In the Iroquois bars there are numerous pits of sandy gravel, which when screened produces four sizes.

(1) Sand used for polishing glass and marble; grains passing the 4-mesh screen.

(2) Gravel for roofing; pebbles passing the 2-mesh screen.

(3) Gravel for reinforced floors and concrete work; pebbles three-quarters of an inch in diameter.

(4) Gravel for road and general foundation work, pebbles between 1 inch and 3 inches.

The gravel bar is underlain by Iroquois sand. Where the Iroquois sand is the top deposit, the upper parts are generally brown, exhibiting bonding power, and at certain places this sand is a moulding sand or a core sand.

The pits are numerous on the north side of Kingston road, and some pits (York Sand and Gravel Limited) produce as much as 100,000 tons a year, half of this material being sand. The mortar sand sells at 35 to 40 cents a yard, sharp sand at about 40 cents, and screened gravel at $1.00 at the pit. As one team can make only two trips a day from the pit to Yonge street, the transportation costs are very high, so that pea gravel costs as much as $2.30 a yard, delivered at Yonge street.

One gravel pit was worked in Summerville, about ten miles west of Toronto. The gravel was brought to the city by motor trucks of 4.5 cubic yards load, making 5 trips daily. This considerably reduced the cost of transport, the cost of an ordinary team being about $6.75 per day.

The run of gravel of the Iroquois bar formation is used by the York Sandstone Brick Co. for making sand-lime bricks. The sandy gravel is screened to eliminate the large stones, and then mixed with 6 to 9 per cent. of slacked lime. This mixture is passed through a Chilean mill crusher, and then into moulding presses, from which the bricks are loaded on wagons, run into big tanks, and submitted for twelve hours to a steam pressure of 125 to 135 pounds. After this time, the bricks are white and hard. It is claimed that these bricks become harder as they advance in age, this phenomenon being probably due to the chemical action of the carbon dioxide of the atmosphere.

Northeast of Toronto, there are some gravel and sand formations near Leaside Junction, where recent gravel is found in the bed of the Don river; also near Aurora, where moulding sand which has been used in the foundry at Aurora, and building sand occurs over a large area. The area between Aurora and Bond lake is very sandy, and contains large reserves. At Maple, four miles west of Yonge street, in lots 22 and 23, concession three of Vaughan township, there are two operators, supplying large quantities of building sand and gravel to Toronto. This material is sold at about 70 to 80 cents a ton in Toronto, of which 55 cents is consumed in freight charges.

SAND AND GRAVEL PRODUCERS, YORK COUNTY.

No.	Owner	Location	Size	Output.	Remarks
1	Allen Bros., Toronto	Birch Cliff, Scarboro tp.	5 acres, 25 ft. gravel, 8 ft. sand	1,500 yd.	Sand & gravel. Screen moved by horse-gear.
2	Bourne & Son, Toronto	Scarboro tp., Kingston Rd			Sand and gravel.
3	E. Ashton, 1352 Queen St. E., Toronto	Scarboro tp., Victoria Park Rd.			4 kinds of sand and gravel.
4	York Sand and Gravel Co., Toronto	Scarboro tp. south of G.T.Ry.	Gravel, 25 ft. deep. Iroquois sand more than 100 ft. deep	95,000 tons	Pit run gravel, screened gravel, mortar, sand and brick sand. Steam shovel of 1,200 tons daily capacity.
5	York Sandstone Brick Co., Toronto	Scarboro tp., South of G.T.Ry.			Sand and gravel for sand-lime brick making.
6	John Foley, 196 Pickering St., Toronto.	Toronto City, east of Pickering St. and north of Kingston Rd	8 ft gravel		Gravel and Iroquois sand.
7	Jackson, 183 Pickering St., Toronto	Toronto City, east of Victoria Park Rd.		Small	Gravel.
8	J. McTague, Malvern Road, Toronto	East Toronto, north of Kingston Rd. and east of Pickering St.	8 ft. gravel	4 yd. a day	Gravel and sand.
9	Maher, Wm., Weston	Weston Rd., Mt. Dennis	35 ft. deep	40 yd. a day	Principally sand.
10	Thompson, Porter, 26 Porter Ave., Mt. Dennis	Mt. Dennis			Sand and gravel.
11	Lochrie, Keele St. and Westminster Ave., Toronto	Toronto			Sharp sand.
12	H. L. Johnson, 56 Soudan Ave., Toronto.	North of Eglinton. Ave. and 1 mile east of Yonge St.			Sand and a little gravel.
13	A. J. Rayner, 244 Broadway Ave., Toronto	North Toronto			Sand.
14	Jos. Billing	Aurora, 1 mile west of Yonge St.			Moulding sand.
15	The Empire Sand and Gravel Co., Maple	100 yds northeast of Maple station	750 ft. long, 50 ft. deep		Building sand and gravel.
16	Maple Sand, Gravel and Brick Co., 178 Spadina Av., Toronto	500 yards north of Maple station	100 ft. deep	40,000 tons	Sand and gravel. Reserve, 80 acres. Steam shovel and steam screen.
17	Frank Pringle, 309 Indian Grove, Toronto	Summerville, 10 miles west of West Toronto	16 ft. deep		Gravel. Reserve, 25 acres. Motor trucks used in transportation.
18	Niagara Power Plant	West Toronto	8 ft. deep		
19	Home Smith Co., Toronto	Keele St., W. Toronto			Gravel.
20		Toronto, Shaw St.			Interglacial sand and gravel.

Granular metric analysis of Iroquois sand, near corner of Gerrard Street and Greenwood Avenue, Toronto:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.03	0.09	0.24	0.39	8.49	71.99	89.49	98.09

Per cent. of fineness 70.13
Coefficient of uniformity 81.09
Grade ..... No. 7
Real specific gravity 2.953
Apparent specific gravity 1.414
Weight in lbs. per cubic foot .. 88.352
Percentage of voids 52.1

Granular metric analysis of sand from lake shore, Toronto Island:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	0.0	0.40	4.75	76.85	98.50	99.60	100.00

Per cent. of fineness 57.77
Coefficient of uniformity 93.75
Grade ..... No. 6
Real specific gravity 3.093
Apparent specific gravity 1.721
Weight in lbs. per cubic foot .. 107.535
Percentage of voids 44.3

Granular metric analysis of sharp sand from interglacial beds, Shaw street, Toronto:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	1.25	2.35	5.80	12.65	67.30	92.85	96.65	98.70

Per cent. of fineness 58.05
Coefficient of uniformity 80.20
Grade ..... No. 6
Real specific gravity 2.844
Apparent specific gravity 1.585
Weight in lbs. per cubic foot .. 99.037
Percentage of voids 44.3

Granular metric analysis of coarse sand, Bourne and Son, Toronto:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	tr.	0.30	0.70	9.55	62.90	84.35	95.60

Per cent. of fineness 71.84
Coefficient of uniformity 74.80
Grade ..... No. 7
Real specific gravity 2.997
Apparent specific gravity 1.654
Weight in lbs. per cubic foot .. 103.349
Percentage of voids 44.8

Granular metric analysis of sand, upper part, Aurora deposit:—

Mesh	4	8	10	20	28	58	80	100	200
Per cent. retained...	0.0	0.0	0.0	0.0	tr.	tr.	0.20	2.30	31.35

Per cent. of fineness 96.24
Coefficient of uniformity 97.70
Grade ..... No. 9
Real specific gravity 3.230
Apparent specific gravity 1.581
Weight in lbs. per cubic foot .. 98.787
Percentage of voids 51.05

Granular metric analysis of sand, central part, Aurora deposit:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.0	0.0	tr.	tr.	tr.	0.30	10.10	28.60	58.60

Per cent. of fineness 89.16
Coefficient of uniformity 71.40
Grade ..... No. 9
Real specific gravity 3.036
Apparent specific gravity 1.667
Weight in lbs. per cubit foot .. 104.161
Percentage of voids 45.1

Granular metric analysis of gravel, Allen Bros., Birch Cliff:—

Mesh	4	8	10	20	28	48	80	100	200
Per cent. retained...	0.35	40.25	64.50	86.70	93.05	96.75	97.45	97.95	98.85

Per cent. of fineness 24.90
Coefficient of uniformity 64.15
Grade ..... No. 2

APPENDIX

Introduction

The following brief report on certain northern Ontario sand and gravel deposits, with the exception of the part dealing with granular metric analyses, was compiled by Prof. A. L. Parsons, of Toronto University, from the notes taken by Professor Ledoux during that part of the field season of 1918 prior to his decease on August 7th.

Granular metric analyses of thirty different samples of sand and gravel, as shown in the table accompanying this appendix, were carried out by H. E. Davis, who is in charge of testing road materials for the Ontario Department of Public Highways. P. A. Jackson, of the Bureau of Mines staff, assisted in the tests. Mr. Davis reports as follows in regard to the methods used:

Specific Gravity of Sand.—The specific gravity was determined by the use of Le Chatelier's specific gravity apparatus, consisting of a flask having a large bulb at the bottom tapering up to a narrow bulb which has a narrow neck of about ¼ inch. The flask is filled with water up to a mark on the lower section of the flask, the distance between this mark and the lower point on the graduations on the upper part of the flask is 20 cc., the narrow neck being graduated into tenths of cubic centimeters. A sample weighing 60 grams was then slowly introduced into the mouth of the flask and the displaced volume recorded.

$$\text{Specific gravity} = \frac{\text{Weight of sand}}{\text{Displaced volume}}$$

Tyler Standard Screens.—For some considerable time there has been a demand for standard testing screens with accurately measured openings that increase or decrease through the series of screens in a fixed ratio. The manufacturer of this screen has established, as a minimum standard, the 200-mesh commercial sieve which has been made of wire .0021 of an inch and having openings of .0029 inch. The scale ratio between the different sizes of screen opening has been taken as 1.414 or the square root of 2, as recommended for ore dressing. Taking .0029 inch, which is the opening of the 200-mesh screen, as the base, the diameter of each successive opening is exactly 1.414 times the opening in the previous screen. It also makes the area or surface of each successive opening on the scale just double that of the next finer or half that of the next coarser screen. In other words, the diameters of the successive sizes are in a ratio of 1.414 while the areas of the successive openings have a constant ratio of 2.

Methods used in conducting Granular Metric Analysis of Sand.—Having thoroughly mixed the samples submitted for test, a quantity of the sand[1] was weighed out and placed on the coarsest screen under which were placed in order the finer screens. The nest of screens was then submitted to a mechanical agitation for about 10 minutes. Screens were then removed and the sand on the coarsest was weighed and recorded. To this was added the sand on the next coarsest screen and the total weight recorded, giving the cumulative weight retained on each screen. To express this in total per cent. retained on any one screen the following formula is used:—

$$\frac{W}{W'} \times 100 = \text{per cent. retained on screen.}$$

where W = total weight of sand before agitation.
and W' = cumulative weight of sand retained on screen.

[1] Sand, as distinguished from gravel, is defined as that part which passes through a ¼-inch screen.

GRANULAR METRIC ANALYSES OF SAND CONTENT OF CERTAIN SAND AND GRAVEL DEPOSITS IN NORTHERN ONTARIO.

District	Description and location of deposits	Laboratory No.	Per cent. retained on Tyler standard screens								Real specific gravity	Per cent. of fineness
			8	10	20	28	48	80	100	200		
Parry Sound...	Parton pit, Parry Sound	15	9.3	17.9	50.7	77.3	96.0	99.9	100.0	100.0	2.69	31.1
" " ...	Beach sand, northwest of Kill Bear point, near Parry Sound	16	.....	.....	2.3	27.5	48.2	99.8	99.9	99.9	2.62	52.8
Nipissing.....	Beach sand, Lake Nipissing, 3 miles south of North Bay	17	.....	.....	.....	.....	11.2	92.0	99.0	99.9	2.69	62.2
"	Bordeleau gravel and sand pit, 2 miles east of Sturgeon Falls	18	13.5	19.7	34.8	46.4	74.6	90.9	95.6	98.4	2.74	40.8
"	Lakeview Park, North Bay, gravel on beach, in front of cottage of Judge Leach	19	2.2	28.9	98.0	99.7	99.7	99.8	99.8	99.8	2.62	21.5
"	Beach sand, Lake Nipissing, south of Sturgeon Falls	20	1.8	4.4	20.3	60.4	98.6	99.1	99.4	99.6	2.61	39.5
"	Gravel pit, Tomiko, mileage 25, T. & N. O. railway	†29	10.9	19.0	47.5	71.7	92.6	97.1	98.2	99.0	2.70	33.0
	Gravel pit, Rabbit Creek, mileage 58.5, T. & N. O railway	*28	21.6	39.2	68.5	81.7	93.0	96.4	97.9	99.3	2.70	25.3
Timiskaming...	Sand, Martineau bay, Lake Timiskaming	30	.....	.1	2.7	16.6	97.9	99.8	99.9	99.9	2.67	47.9
" ...	Sand, Chambers-Ferland pit, Cobalt	27	.1	.2	2.3	7.3	40.8	70.1	84.2	95.8	2.67	62.4
" ...	Sand near Nellie Lake station	2	.....	.....	.05	.1	3.5	36.1	69.4	93.2	2.68	74.7
" ...	Nellie Lake pit, T. & N. O. railway, sandy gravel	4	.....	.05	2.7	17.5	72.7	94.0	99.1	99.8	2.65	51.8
" ...	Nellie Lake ballast pit, fine gravel at bottom of pit	*7	18.5	35.2	78.2	96.8	99.4	99.5	99.5	99.5	2.67	21.7
" ...	Fine sand, Cochrane	9	.....	.....	.....	.1	.4	3.0	12.0	55.3	2.73	91.1
" ...	Gravel from ballast pit, 2 miles south of Cochrane	5	19.9	34.9	63.7	79.6	91.9	95.0	95.9	96.8	2.67	27.8
" ...	Sand at south end of ballast pit, 2 miles south of Cochrane	11	.1	.3	3.9	19.9	82.8	97.7	99.3	99.6	2.67	49.5
" ...	Sand, road west of Timmins	24	.....	.1	.15	.2	.4	8.4	39.1	82.3	2.64	83.7
" ...	Sand, east of Timmins	21	1.0	2.1	6.3	14.6	58.7	89.9	96.7	99.5	2.69	53.9
" ...	Gravel, east of Timmins	25	9.6	15.2	33.2	53.2	91.1	98.5	99.3	99.4	2.65	37.6
" ...	Coarse sand, east of Timmins	26	.9	2.7	10.2	22.1	71.5	95.0	98.1	99.3	2.65	50.0

GRANULAR METRIC ANALYSES OF SAND CONTENT OF CERTAIN SAND AND GRAVEL DEPOSITS IN NORTHERN ONTARIO.—*Continued.*

District	Description and location of deposits	Laboratory No.	Per cent. retained on Tyler standard screens								Real specific gravity	Per cent. of fineness
			8	10	20	28	48	80	100	200		
Timiskaming..	Drinkwater pit, Porcupine branch, T. & N. O. railway	22	.8	1.2	2.0	3.5	20.0	56.7	82.2	94.5	2.63	67.4
" ...	Barber Bay, pit near the track, Porcupine branch, T. & N. O. railway	*23	24.9	38.1	60.7	75.9	92.9	96.9	98.0	99.9	2.69	26.6
" ...	Town of Cochrane gravel pit, located 1 mile north of town	*3	6.4	13.5	41.7	64.3	93.3	98.8	99.8	99.8	2.61	35.3
" ...	Sand from pit, 1 mile north of Cochrane near pumping station	8	.05	.07	.1	.2	6.1	52.0	82.8	97.5	2.65	70.1
" ...	Buskego, Canadian National Railway, mileage 9, west of Cochrane	6	4.1	8.7	28.6	49.0	90.4	96.7	97.7	98.5	2.65	40.8
" ...	Coarse sand, Buskego pit, west of Cochrane	1	.3	.5	2.1	7.3	68.6	95.2	97.9	98.6	2.70	53.7
" ...	Gravel pit, 1 mile south of mileage 57, near Moonbeam, Can. Nat. Ry.	13	10.3	27.3	72.0	90.4	99.7	99.9	99.9	99.9	2.69	25.1
Algoma.....	Gravel hill, 4 miles west of Hearst, Can Nat. Ry.	*16	9.0	22.6	64.2	79.4	88.9	92.9	94.7	97.0	2.62	31.4
"	Coarse sand, 4 miles west of Hearst	12	.....	.2	18.4	65.1	95.7	98.8	99.4	99.9	2.55	40.3
"	Moulding sand on top of hill 4 miles west of Hearst	14	.....	.....	.1	.2	.7	1.2	3.4	18.9	2.69	96.9

*Material suitable for concrete work.

†Quartz and feldspar grains from disintegrated gneiss predominate.

Parry Sound District

The district as a whole is very rocky, the outcrops being mostly granite, gneiss and other related pre-Cambrian rocks. The glacial Lake Nipissing once extended over this whole region, the smaller lakes at present scattered through the district being the remnants of the large lake after the water level had been lowered.

Deposits of gravel, sand and clay were laid at various depths in these waters and some of them are still found on the slopes of the hills.

Several deposits may be noticed in the vicinity of the town of Parry Sound. One mile north of the town there is a ridge of sand and gravel running north 45° east, mostly on the west side of the road. The graveyard is located on part of it.

Argue's sand pit, Parry Sound.

The length of the ridge is about 800 yards and the width 200 yards. Several pits located on the properties of Messrs. Argue, Parton and Reece Hall have been opened in this ridge.

Argue's pit is located just north of the cemetery, on the west side of the road, the excavation being 75 by 36 by 12 yards. The material is mostly sand, well suited for building purposes, the deposit showing oblique stratification. The north portion of it contains more pebbles and grades into a gravel. Some large boulders are found. As a rule the pebbles are granite and gneiss, although sometimes an odd pebble of limestone is found. The sand is coarse and contains quartz as its principal constituent. Feldspars and dark ferro-magnesian mineral grains are also abundant.

The deposit lies about 100 feet above the level of the Seguin river or 700 feet above sea level. This material is sold at about 40 cents a load at the pit. The reserve is 125,000 cubic yards approximately.

Parton's pit lies 500 yards to the north, on the east side of the road, in lot 28, Con. II, of McDougall township. Both sand and gravel occur, with gravel predominating in some parts. The present excavation is 40 by 20 by 10 yards in size, the reserves being 20 acres in area, mostly all gravel. If the average depth is calculated at ten yards, the available material would total 48,400 by 20 = 968,000 cubic yards. The output in 1917 was about 2,000 cubic yards, this material being sold at 15 cents for road gravel and at 25 cents for average cement gravel. The gravel is of good quality, most of the pebbles being of granite and other pre-Cambrian rocks, and very few of limestone. The deposit lies at an altitude of about 740 feet[1] above sea level.

Reece Hall's pit is located east of Parton's, and a little south of Mill lake. The excavation measures 60 by 12 by 10 yards, and lies at about the same level as the Parton pit. The east side of this gravel pit shows rock outcrops.

Four miles north of Parry Sound, on the east side of the northern road, there is a small sand and gravel pit 30 by 15 by 3 yards in size, located on a ridge crossing the road in an east and west direction. The pit belongs to John Draper.

One mile north of Waubamick station, on the C. N. Ry. line, there is a large pit containing mixtures of sand, clay and gravel. The material is used as ballast for the railway, and the present excavation is 400 by 150 by 12 yards, corresponding to a removal of 720,000 cubic yards. The pit has been idle for several years, but is to be worked again. The necessary equipment, including steam shovels, has been provided, and the railway company intends to take out during the summer of 1918 approximately 60,000 cubic yards. This deposit lies 850 feet[1] above seal level.

Another pit on the same large deposit of sand and gravel, but farther east, will be opened about one mile northeast from Waubamick station. This material is to be used principally for filling work.

The deposits around Waubamick lake were probably formed in an old bay or tributary of Long lake. The deposits near Parry Sound graveyard were formed by Mill lake, while the ridge on which J. Draper's pit is located is connected with a former stage of the history of Portage lake.

On the shore of Georgian bay and on the numerous islands located in Parry Sound the deposits of sand and gravel are few in number and as a rule of small extent. Between 2-Mile point and 3-Mile point there is a small sand beach about 75 yards long, the result of weathering of the rocks of Parry island. There are two little sand beaches about 30 yards wide near the lighthouse at 3-Mile point on Parry island. At Kill Bear point, about 200 yards east of the lighthouse, there is a sand beach about 100 yards long.

Northwest of Kill Bear point there is a large sandy beach extending around the bay in Con. VIII, McDougall township, for about 1,500 yards, but in no place wider than 200 yards. The sand contains numerous clear transparent quartz grains, some feldspar and brown ferro-magnesian minerals. There is only a narrow strip near the shore not covered by vegetation.

[1] Aneroid determination.

Sandy island, located in Georgian bay, about three miles from Parry island, is composed entirely of sand, with some large pebbles along the southeastern shore and smaller pebbles along the northern shore. This island has an area of about 1,000 acres, and is covered with wood, but contains a large reserve of sand resulting from the weathering of granitic and gneissoid rocks. The average elevation of the island is not more than 60 feet above Georgian bay. Black mineral grains and vegetable matter are intermixed with the sand. All round the island the water is very shallow for about 500 yards from the shore. Large quantities of material are recoverable by dredging. The sand at Sandy island is of a finer size than the sand of Kill Bear point, where it is coarse and whiter. The upper part of the Sandy island deposit looks white when dry, but it contains ferruginous elements, and as soon as digging is done black and brown sand are found. This island belongs to Walter L. Haight, Parry Sound.

There is a sandpit along the Canadian Pacific railway tracks near Shawanaga station, and also between Parry Sound and Byng Inlet, along the shore of Georgian bay. Small pockets of sand overlaid by mud are found in the bay opposite Franklin island, on Shebeshekong beach. Further north the islands in Georgian bay are more and more rocky.

Along the road through the bush from Parry Sound to Rose Point small deposits of angular gravel occur, resulting from the disintegration of underlying diabases, pegmatites and gneisses. Large quantities of poor sand were excavated for ballast at Depot Harbour on Parry island, in the cuttings of the Grand Trunk railway, near James bay junction and at Otter lake. This material is very often ferruginous, brown in colour and contains a certain amount of silt and angular fragments of the underlying rocks.

Near Whitehall and Sprucedale, in concessions X and XI of McMurrich township, local deposits of sand and gravel are not uncommon. East of Whitehall station, a large excavation, 15 feet deep, was made along the G. T. railway tracks for ballast supply. The sand is very often brown, due to vegetable matter from resinous trees which it contains.

There are also some deposits and excavations between Sprucedale and Scotia Junction. The country between Scotia Junction and Kearney along the G. T. railway is very sandy, and several railway cuts pass through deposits 25 feet in thickness. The adjoining territory in Bethune township is covered by a sandy soil, which has been used to some extent for railway ballast.

Near Ravensworth, the last station on the G. T. railway in Parry Sound district, the altitude rises to 1,400 feet, and small local sand pockets are found at this level. An excavation 800 by 100 by 37 yards has been made along the tracks for supplying ballast.

Between Scotia Junction and Burks Falls there is a great alluvial plain made mostly of sand and silt. Near Emsdale, at Burk's Falls, and at other local occurrences, the quality of this material is better, and it has been worked for sand or road gravel. The proportion of clay is, as a rule, too great, and on the roads this material is soon reduced to dust.

About one mile northwest of Burks Falls there is a sandy ridge at an altitude of 680 feet above sea level. The ridge is made of sharp sand, except at the

surface of the deposit, where it is mixed with clay and pebbles. At Carss station there is also some sandy material lying 675 feet above sea level (aneroid measurement).

At mile 172, on the G. T. railway, near Burks Falls, a gravel ridge crosses the line and is seen in the cuttings with boulder clay and sand, having a total depth of 10 yards. It is also met on the shores of a tributary of the Maganatawan river. This material was used for ballast.

Seven miles east of Burks Falls the fine sand beach on the southern shore of Pickerel lake is capable of supplying thousands of tons of clean washed sand.

In Burks Falls, half-way between the station and the mill, there is a gravel pit 30 yards long and 15 yards deep, containing large boulders of gneiss, banded quartzite, etc., and some clay. In the centre of the town, there is a large gravel pit belonging to the municipality. The present excavation is 75 by 20 by 8 yards in size, and the pit supplies both sand and gravel. The stratification is oblique.

In the township of Ryerson there are two pits about nine miles west of Burk's Falls.

In the township of Armour the following pits were noticed:

1. Chas. Freer's pit.
2. A. Hego's pit at Barriedale, supplying gravel.
3. D. J. Van Meer's gravel pit (clean material sold at 25 cents a load).
4. John Hughes' pit.
5. G. T. railway gravel pit, on lot 14, Con. XIII. The present excavation is 300 by 30 by 15 yards in size. The gravel is of good quality for railway work.
6. Knight Bros.' gravel pit. This material is used for roadwork.

In the northeastern corner of Parry Sound district there are large areas of sand near Trout Creek station, between Powassan and Burks Falls. Near Powassan there is a sandpit 200 by 15 by 5 yards in size along the east side of the G. T. railway tracks. Outcrops of gravel are met in the cuttings of the railway between Powassan and Callander.

The area south of lake Nipissing is a plateau lying about 125 feet above the water level of the lake. It consists of rounded rocky hills, often showing glacial striae and at some places it is covered by residual or maraine deposits of unassorted sand and gravel. The southern shore of lake Nipissing itself is mostly a sand beach, the material being of various grades in different localities. The finest beach sand in some places has been driven two miles inland by the wind. There are also some scattered deposits of gravel along the shore of lake Nipissing.

Nipissing District

Going from North Bay along the Temiskaming and Northern Ontario railway sandy material is shown in a cut about 3.5 miles north. This appears to be derived from the weathering of the underlying rock.

Near Trout Mills (mileage 7.5) there is an old pit about 300 by 30 by 10 yards in size. The material was largely used for fills on the railway, as it was rather dusty for ballast. Very little was taken out in 1917.

At mile 25 is a pit 250 by 15 by 5 yards, extending in a N.E. and S.W. direction. Toward the S.W. end the thickness of the deposit is not so great as at the N.E. end.

The material is a clean gravel, while at the N.E. end it is a coarse sand well suited for building. In size the material ranges from sand to boulders one to two feet in diameter, and the rocks from which it is derived are granite, gneiss, conglomerate, diabase, quartzite, and other rocks, principally intrusive. The pit lies north of a small lake, and this deposit probably represents the shoreline of the lake when it was at a higher level. For the past two years the pit has not been worked.

Near Tomiko station is a large abandoned pit, about five yards deep, from which filling and ballast were obtained for the building of the railroad.

At Rabbit Creek, mileage 58.5, is a pit on the east side of the railway, about 500 by 100 by 10 yards, from which ballast of good quality has been secured. Boulders are not numerous. The bulk of the material consists of gravel ranging in size from ¼ inch to 3 inches in diameter, and the pit is worked intermittently by steam shovel. The upper portion of the deposit consists of sand. At the east end of the pit bed rock is encountered, and rock outcrops are shown to the north of the pit.

North of Doherty station and just south of Twin lake, is another large gravel pit from which ballast was obtained for a revision of the line near Doherty.

About one mile northeast of Cassidy station is a pit 800 by 25 by 7 yards in size. This is a coarse gravel, with numerous boulders ranging from six inches to one foot in diameter. The pebbles are predominantly granite and gneiss. Large reserves are still available.

Timiskaming District

Between Haileybury and New Liskeard the shore of lake Timiskaming and the adjoining slopes are covered with clay. Near the shore several masses of rocks of the Cobalt series outcrop in dome-like hills. Sometimes a little sand is found on the surface in a layer one to two feet in thickness overlying the clay, but these deposits are local. After stormy weather a certain quantity of sand and gravel is deposited on the lake shore. The fragments are angular and small. The predominant rock in the gravel is a light-coloured limestone of Silurian age containing numerous fossils.

Along the lake shore south of Haileybury toward North Cobalt the composition of the gravel changes and pre-Cambrian rocks are more prominent. There are large reserves of this surface material, and it has been used for building operations.

Around Martineau bay of L. Timiskaming is a deposit of sand well suited for building purposes. The sand extends along the slopes of the adjoining hill and can be seen on both sides of the old Mission road. Large quantities of clean sand are available, which could be transported by scows to points on the lake.

MAIN LINE, T. AND N. O. RAILWAY

Cobalt and Vicinity.—Near the North Cobalt school-house a small deposit of sand has been worked. This is mixed with gravel and is only about a foot in thickness.

The sand pit of the Chambers-Ferland mine near mile 104 is an excavation 80 by 40 by 5 yards. Most of the available material has been removed. It is principally light-coloured sand, which contains patches of gravel.

To the west of mile 104 on the T. & N. O. Ry a gravel pit parallels the railroad on the ridge near the cemetery. The size of the excavation is 75 by 10 by 3 yards. The gravel is varied in composition, consisting principally of rocks of the Cobalt series and granite. A little further west is another excavation about half as large containing a good amount of small gravel. This is screened for use in concrete work.

About 2½ to 3 miles west of West Cobalt the soil becomes more sandy and contains a large proportion of pebbles. Near the powder factory it is a gravel. Small pits have been opened along the road for road building.

In lot 10, Concessions IV and V, township of Coleman, is a pit about a mile long, 50 yards wide and 15 yards deep. The material is principally a mixture of sand and gravel, but at some places clay is visible in the walls. The pebbles rarely are more than one foot in diameter, but occasional boulders as much as 3 feet in diameter were seen. Basic igneous rocks are prominent, though granite and gneiss are abundant. Large reserves are still available.

Nellie Lake.—Nellie Lake station, township of Calvert, is in the midst of a sandy plain, which extends about 500 yards east and about 1,500 yards west. Since the fire of 1916 this plain has been covered with partially burned forest. Just east of the station is a small kettle lake, the level of which is about 60 feet lower than the station. The altitude of the station is about 1,000 feet, but about 500 yards east of this point and about 150 feet above the level of the plain there is a sand ridge consisting of a series of hills ranging from 300 to 500 yards in length, with a width of from 200 to 300 yards. This ridge is approximately parallel with the T. & N. O. Ry.

A pit has been opened on the west side of one of these sand hills and a railway siding has been extended to the pit. Both sand and gravel have been obtained, the finer grained material being near the surface. The gravel is quite variable in size, and contains boulders up to 18 inches in diameter. This pit is about 250 by 7 by 2 yards. Just to the east of this, along the same railway siding, a larger pit has been opened. The gravel is apparently reassorted glacial material, consisting of pebbles of granite, gneiss and quartz. A line of kettle lakes between the pits and the railway gives further confirmation of the glacial origin of these deposits.

Distinct bedding in the deposit was not observed, but the face of the workings is not fresh, and the falling of the upper portion has probably masked the true condition.

Cochrane.—About one mile north of Cochrane there are several kettle lakes, surrounding which are deposits of morainic origin. To the west of the pumphouse there is a sand pit about 20 yards in diameter by 5 yards deep, which furnishes building sand.

A little further north, between two kettle lakes, is a gravel ridge in which is a pit known as the town pit. The gravel is cross-bedded and consists of small pebbles. The present excavation is about 75 by 25 by 7 yards, with a reserve of about equal dimensions.

About two miles southeast of Cochrane is a large gravel pit in a ridge to the east of a kettle lake. This pit is about 800 by 40 by 10 yards, and furnished ballast and filling for the T. & N. O. railway.

PORCUPINE BRANCH, T. AND N. O. RAILWAY

Timmins.—Sand and gravel has been taken from a pit south of the road from Timmins to Schumacher. The pit is about 12 feet deep and 15 yards in diameter. As a rule the pebbles are not more than four inches in diameter, and are composed of granite, gneiss, schists and basic igneous rocks. This material has been used for roads and building. Another pit on the same side of the road is about 75 by 25 by 7 yards, and has been practically exhausted. On the opposite side of the road is a pit near the railway which is more sandy, but furnishes material used for building.

Drinkwater pit.—On the north side of the railway is a pit 300 by 30 by 10 yards which has been abandoned.

Connaught.—At Connaught station a steam shovel was operating a gravel pit in 1917 and 1918, and 230 car loads were shipped.

Barber Bay.—Northwest of the railway there is a pit about 200 yards long by about 40 to 50 yards wide, with an average depth of 5 yards. Large boulders are not numerous, the average not exceeding four inches in diameter. The pebbles consist of gneiss, granite, schist, and greenstone. There is a large reserve yet available at this pit.

CANADIAN NATIONAL RAILWAY

Buskego.—About eight miles west of Cochrane a pit 600 by 100 by 15 yards furnished a sandy gravel which in some portions has been cemented by calcareous solutions. This was used for ballast on the Canadian National Railway, formerly called the National Transcontinental.

Drainage of some of the small lakes surrounding the pit could be effected easily and permit 20 feet additional depth to be worked by steam shovel.

Moonbeam.—A little west of Moonbeam, on the railway, near mile 57 (west of Cochrane), an old siding branches to the south to several ballast pits. The first of these is about a mile south of the track, and shows an excavation about 300 yards long by 15 yards wide and 10 feet deep. The upper portion of the deposit is sand, but the lower part is good, clean gravel suitable for concrete. The gravel is chiefly derived from Laurentian rocks, and the pebbles are usually small, though boulders as large as three feet in diameter are found.

About 1½ miles south of this first pit is another about 400 yards long by 50 yards wide and 10 yards deep. The character of the deposit is practically the same as in the first pit.

A third pit two miles south of the second one shows an excavation 300 yards by 20 yards by 5 yards in a ridge between two narrow lakes. The gravel is somewhat coarser than in the first two pits, and is suitable for ballast. One mile south of this pit is a fourth pit in a hill about a mile long by 400 yards wide and a maximum height of about 30 yards. The gravel is fairly coarse, with numerous pebbles from four to six inches in diameter, and boulders as large as six feet in diameter in places. The pebbles are principally derived from pre-Cambrian rocks, and consist of granite, gneiss, quartzite, and greenstone. There is a large reserve in this pit.

Harty.—About 400 yards south of Harty, mile 81, is a pit about 600 by 30 by 6 yards, which furnishes gravel for ballast. There is still a reserve.

Algoma District

CANADIAN NATIONAL RAILWAY

Mattice.—Near mileage 100.3, just east of the bridge over the Missinabi river, lot 27, con. IV, Eilber township, is an old pit from which gravel was obtained for ballast and concrete for the bridge piers. The excavation is about 80 by 40 by 5 yards, with possibly an equal reserve left. The pebbles consist of granite, gneiss, and limestone.

To the northeast of this pit, in lot 26, Con. IV, Eilber township, is a larger pit 400 by 50 by 5 yards, which furnished ballast. This deposit is practically exhausted, and the railway siding has been removed.

Hearst.—Four miles north of Hearst is a hill about 30 to 40 feet above the general level which is somewhat loamy in places. At a depth of three or four feet sand suitable for concrete, plastering and brick-work has been found. This hill extends for about a mile and a half in a N.E-S.W. direction. In some places gravel suitable for roads and concrete is encountered. The pebbles range from an inch or an inch and a half down to the size of a grain of wheat. The gravel is quite clean, particularly near the bottom of the pit. The hill is about 400 yards wide and about 15 yards high, and would probably furnish 10,000,000 cubic yards. Over some parts of the hill a deposit of moulding sand ranging from one to two feet in thickness is found.

ALGOMA CENTRAL AND HUDSON BAY RAILWAY

Hearst to Hawk Junction.—Between Hearst and Oba no sand or gravel deposits were observed. The first deposit of this kind was seen near Lake Oba. These deposits were used for ballast by the Algoma Central and Hudson Bay railway. Deposits of a similar character occur near a number of lakes in this region. Between Franz and Hawk Junction the country is more rocky, but several large silty gravel hills were seen along the railway.

Michipicoten River.—North of Michipicoten river there is a sandy beach with several terraces above. The sand in the terraces is not very clean, but large reserves are available for water transportation. The beach sand is clean and would probably furnish good building material.

Wawa Station.—One-half mile south of Wawa station is an old ballast pit which was used by the Algoma Central & Hudson Bay railway. The material is a sandy gravel.

Hawk Junction to Sault Ste. Marie.—Along the line of the Algoma Central and Hudson Bay railway from Hawk Junction to Sault Ste. Marie there are numerous terraces at different elevations which would furnish large quantities of sand and gravel. Material has been taken from some of these for ballast for the railway.

but with the exception of a few pits near Sault Ste. Marie none of them have been used for any other purpose. Until this region is more thickly settled, there is little prospect of these deposits being utilized.

Sudbury District

Sudbury.—On the south side of Elm Street West there is a large deposit of sand and gravel that has been used extensively for building purposes. All grades from fine sand to gravel with pebbles two inches in diameter are found. As a rule the several grades are very clean, and the gravel is suitable for concrete work.

The highest point of the deposit is 920 feet above sea level, and the thickness is about 25 feet. Outcrops of rock are shown in the bottom of the pit.

The material consists principally of fragments of quartz and basic rocks, probably of the Sudbury series. Oblique bedding is shown, and evidently the deposit is found under water. The sand on the surface has been subjected to the action of wind, so that some parts of the deposit now present a dune-like appearance.

CANADIAN PACIFIC RAILWAY

Cartier.—About one mile north of Cartier station and west of the railway tracks is a terrace about 20 feet higher than the tracks. A pit about 400 yards long has been worked here for railway ballast. At present the pit is not in use, The material appears to be chiefly sand. The region here is a sandy plain, with a number of rocky hills, and covered with numerous boulders of granite and similar rocks.

Larchwood to Levack.—Half a mile northwest of Larchwood the Canadian Pacific railway crosses the Vermilion river, which flows between banks of sand and clay. About two miles west of Larchwood, where the track turns to the west, the railway cuts through a ridge of sand about 50 yards wide and about 30 feet high. This sand is horizontally stratified. The ridge runs in a northwest direction more or less parallel with the railway for a third of a mile, and can be followed for more than a mile. In the railway cut the material is fine-grained sand, but near Phelan it develops into a large gravel deposit, which has been worked as a ballast pit. The present excavation is about one-half mile long, 100 yards wide, and about 15 yards deep. The gravel is quite clean and contains few pebbles more than six inches in diameter. The small pebbles are not much rounded, indicating that they had not been transported a great distance. The pebbles consist principally of granite, diabase, gabbro and sandstone, and the upper portion is as a rule sandy.

The north end of the pit is worked at present by steam shovel. Here alternating beds of sand and gravel of different grades showing oblique stratification are shown. The intermixture of these by the steam shovel gives a product not as clean as the gravel, near the centre of the pit, which is of excellent quality for concrete work. The material is used for filling and ballast. In 1917 the average production was from 2,000 to 3,000 yards per day for four months. This pit was first opened about 35 years ago, but was idle for many years. A large reserve, several hundred yards wide, remains.

Windy Lake.—About one mile south of Windy Lake station there is a large gravel pit which was used for ballast but is now abandoned. This pit is about 1,500 by 75 by 10 yards in size. It is located in a terrace to the north of Windy lake and on the west side of the railway. The reserve in this deposit is probably three times the amount taken out. Near the centre of the pit the gravel is very clean, and would be suitable for concrete work. Towards the ends of the pit the material is more loamy, but the upper part has fallen over the face so that the stratification is concealed and it is impossible to tell what proportion of clean sand or gravel is present.

End of Part II

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